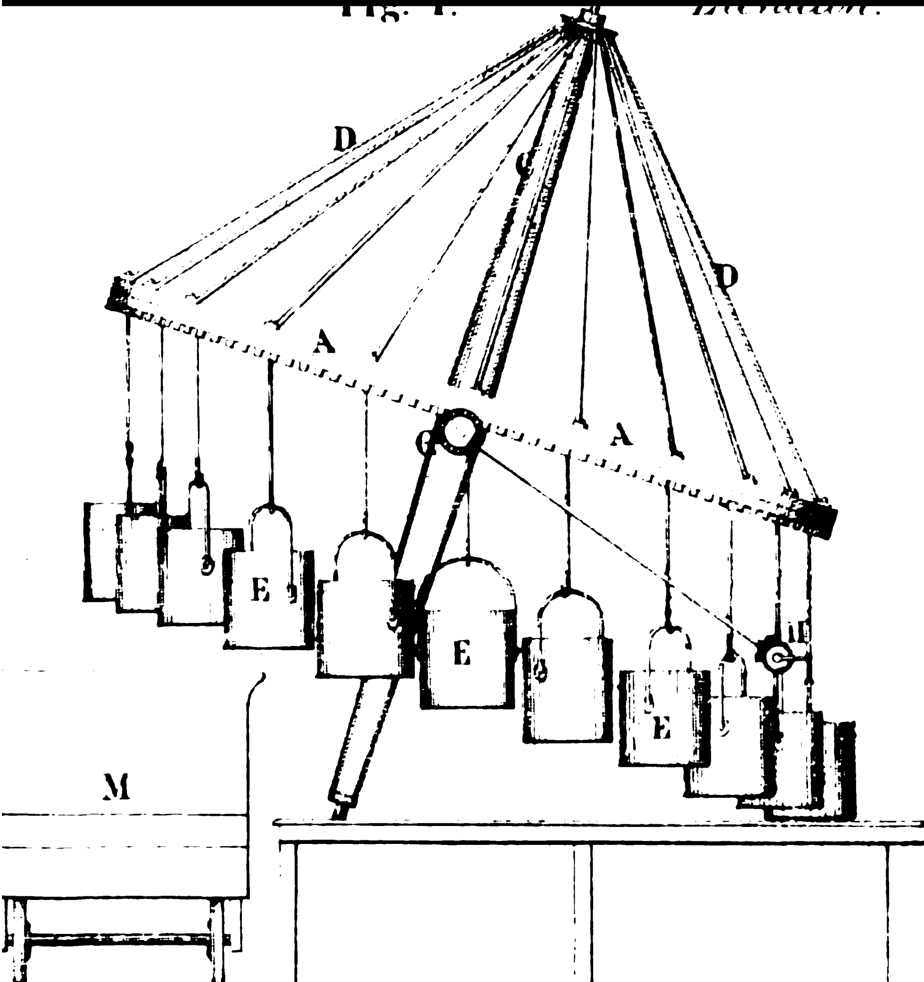

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FAN BLAST.

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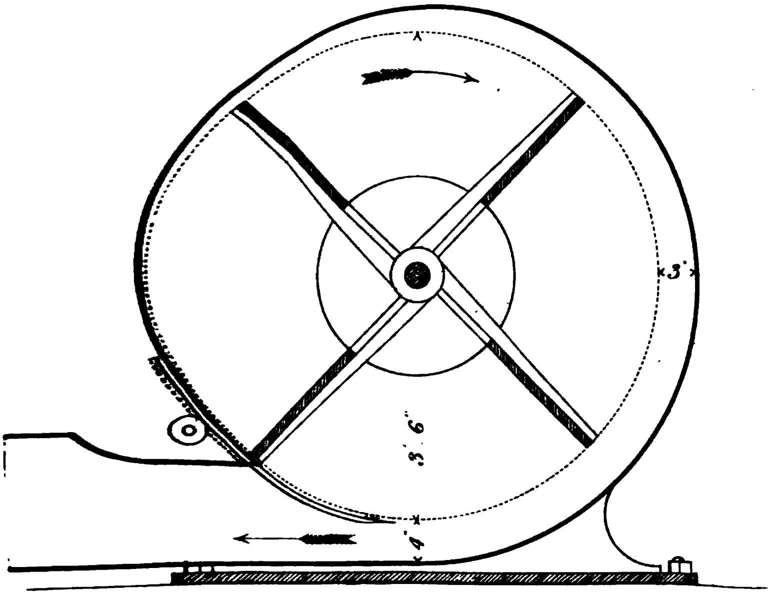
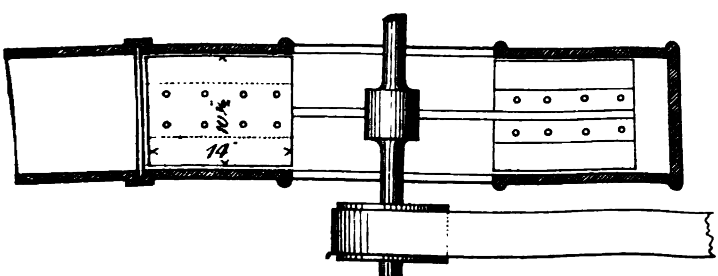


Sectional Plan.



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INSTITUTION

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MECHANICAL ENGINEERS.

EXPERIMENTS

ON

THE FAN BLAST,

BY

WILLIAM BUCKLE.

PAPERS READ AT THE MEETINGS AT BIRMINGHAM,

17TH MAY AND 27TH OCTOBER

1847.

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EXPERIMENTS ON THE FAN BLAST.

By Mr. William Buckle, of Birmingham.

The present paper has reference to a portion of a series of Experiments on the Fan Blast,—a subject which many members of this Institution are conversant with; but it is hoped that the hints here thrown out may be serviceable in leading to such constructions of the fan as shall ensure the greatest useful effect with the least expenditure of power. The fan has become an indispensable machine in smithies and foundries; it abridges time and labour, and is otherwise a great improvement over the old system of bellows. The puffy blasts of the latter admit of no comparison with the uniform stream obtained by the fan. By means of the fan the smith can heat his work with precision, can vary at discretion the size of his nozzle tuyere, without deteriorating the density of his blast; and can conveniently heat one piece of work while shaping another.

In a well regulated smithy, the main pipe from the fan is furnished with an air chest and with nozzle pipes varying from 1 to 3 inches diameter. The pressure of the blast is made to range from 4 to 5 ounces per square inch. A nozzle pipe of 1⅝ inch diameter is found a suitable size for general engine forgings.

The position of the fan in its chest, that is preferred and generally adopted, is an eccentric position. The continually increasing winding passage between the tips of the vanes and the chest serves to receive the air from every point of the circumference of the fan, and produces a general accumulating stream of air to the exit pipe. The particles of air having passed the inlet opening, and entering on the heel of the vane, would retain the same circular path, were it not for the centrifugal force of the air due to its weight and velocity impelling them forward towards the tips of the vanes, and this continued action is going on, particle following particle, till they are ultimately thrown against the fan chest, and are impelled forward to the exit pipe. It is by this centrifugal action that the air becomes impelled and accumulated into one general stream. But, as will be presently sl

there is a certain velocity of the tips of the vanes which best suits this action.

An ordinary eccentric-placed fan, 4 feet diameter, with vanes 10 inches wide and 14 inches long, and making 870 revolutions per minute, will supply air at a density of 4 ounces per square inch, to 40 tuyeres, each being $1\frac{5}{8}$ inch diameter, without any falling off in density. The experiments herein detailed were made with a fan 3 feet $10\frac{13}{16}$ inches diameter, the width of the vanes being $10\frac{3}{4}$ and the length 14 inches; the eccentricity of the fan $1\frac{7}{16}$ inches, with reference to the fan case, the number of vanes being 5, and placed at an angle of 6° to the plane of the diameter; the inlet openings on the sides of the fan chest $17\frac{1}{2}$ inches diameter, the outlet opening 12 inches square; the space between the tips of the vanes and the chest increasing from $\frac{3}{8}$ inch over the exit pipe to $3\frac{1}{2}$ inches at the bottom at a point perpendicularly under the centre. To the blast pipe leading to the tuyeres a slide valve was attached, by means of which the area of the discharge was accurately adjusted to suit the required density.

These experiments were made with a view to ascertain what density or pressure of air could be obtained, with the vanes moving at given velocities, the outlet pipe being closed; and also at given velocities, with the outlet open, but its area varied at discretion; and further, to ascertain the horse power required to drive the fan under these several conditions.

The gauge to indicate the density or pressure of the air was a glass graduated tube, primed with water, it being more sensitive and having a greater range than the mercurial one.

The horse power was ascertained by an indicator, the friction of engine and gearing being deducted in each experiment. With reference to the term Theoretical Velocity, as used in the table, it may be necessary to observe, that by this is meant the velocity which a body would acquire in falling the height of a homogeneous column of air equivalent to the required density. Having given the above preliminary explanations, we come to the experiments as recorded in the following table.

The 1st column is the number of the experiment.
The 2nd is the number of revolutions of the fan per minute.
The 3rd is the velocity of the tips of the vanes in feet per second.
The 4th is the density or pressure of the air in ounces per square inch, as indicated by the gauge.

The 5th is the height in inches of a column of mercury equivalent to the density.

The 6th is the height in feet of a column of air equivalent to the density.

The 7th is the area of the discharge pipe in square inches.

The 8th is the indicated horse power.

The 9th is the theoretical velocity of the air in feet per second.

The 10th is $\frac{9}{10}$ths of the theoretical velocity of the air in feet per second.

The 11th is the theoretical quantity of air discharged in cubic feet per second.

The 12th is the centrifugal force of the air per square inch, calculated from the theoretical velocity.

By this paper it is intended to show that there are certain velocities with which the tips of the vanes of a fan should move, according to the required density of air, and that there are certain laws which govern these velocities.

Water is 827 times heavier than air, and mercury is 13·5 times heavier than water; consequently mercury is 11164 times heavier than air. A column of mercury one inch in height would therefore balance a column of air 11164 inches or 930·3 feet in height.

A column of mercury 30 inches in height produces a pressure of 15 lbs. per square inch; hence a column of mercury 1 inch in height gives a pressure of $\frac{1}{2}$ lb. or 8 ounces per square inch; and therefore a column of mercury $\frac{1}{8}$ inch in height will give a pressure of 1 ounce per square inch. Consequently the height in inches of a column of mercury equivalent to any given pressure or density is found by dividing the density in ounces per square inch by 8.

Let A be the height in inches of a column of mercury equal to any given density, and let B represent 930·3, and C 64 *; then $\sqrt{(A \times B \times C)} = \sqrt{(A \times 930{\cdot}3 \times 64)} = V =$ the velocity that a body would acquire in falling the height of a column of air equivalent to the density.

The centrifugal force of air coincides with the results obtained by the laws of falling bodies, that is when the velocity is the same as the velocity which a body will acquire in falling the height of a

* The space which a gravitating body will pass through in one second is $16\frac{1}{12}$ feet; but by the principle of accelerating forces, the velocity of a falling body in one second is equal to twice the space through which it has passed in that time, or the velocity in any given time is equal to the square root of the number obtained by multiplying 64 by the height in feet.

TABLE OF EXPERIMENTS.

1	2	3	4	5	6	7	8	9	10	11	12
No. of Experiments.	Number of Revolutions of Fan per Minute.	Velocity of Tips of Vanes in Feet per Second.	Density of Air in Ounces per Square Inch.	Height of Mercury in Inches equivalent to Density.	Height of Column of Air in Feet equivalent to Density.	Area of Discharge Pipe in square Inches.	Indicated Horse Power.	Theoretical Velocity of Air in Feet per Second. *	9-10ths of Theoretical Velocity of Air in Feet per Second. *	Theoretical Quantity of Air discharged in cubic Feet per Second.	Density of Air calculated by Laws of Centrifugal Force in ounces per square Inch.
No. 1	1160·0	236·80	9·40	1·18	1093·10	0	9·60	264·40	237·96	0	9·30
2	1081·7	220·80	7·90	0·99	918·20	0	7·54	242·40	217·80	0	7·80
3	1000·0	204·16	6·90	0·86	801·91	0	6·68	226·50	203·85	0	6·80
4	907·5	185·28	5·60	0·70	651·21	0	5·36	204·10	183·69	0	5·50
5	840·0	171·50	4·50	0·56	522·80	0	3·82	182·90	164·61	0	4·40
6	705·8	144·10	3·50	0·44	406·50	0	2·21	161·20	145·08	0	3·40
Fan discharging Air at a Density of SEVEN Ounces per square Inch											
7	1086·6	221·80	7·00	0·88	814·01	37·50	13·31	228·24	205·40	59·40	6·92
8	1063·3	217·09	7·00	0·88	814·01	38·13	11·02	228·24	205·40	60·40	6·92
Fan discharging Air at a Density of SIX Ounces per square Inch.											
9	1086·6	221·80	6·00	0·75	697·72	48·75	13·81	211·30	190·17	71·50	5·93
10	1045·0	213·30	6·00	0·75	697·72	53·13	12·54	211·30	190·17	77·91	5·93
11	941·6	192·20	6·00	0·75	697·72	24·38	6·43	211·30	190·17	35·71	5·93
Fan discharging Air a Density of FIVE Ounces per square Inch.											
12	1086·6	221·80	5·00	0·63	581·43	60·00	14·26	192·90	173·61	80·37	4·94
13	1035·8	211·48	5·00	0·63	581·43	65·00	13·05	192·90	173·61	87·00	4·94
14	950·0	193·90	5·00	0·63	581·43	52·50	8·75	192·90	173·61	70·32	4·94
15	855·0	174·50	5·00	0·63	581·43	22·50	4·53	192·90	173·61	30·00	4·94

				Fan discharging Air at a Density of FOUR Ounces per square Inch.								
16	1086·6	221·80	4·00	0·50	465·10	69 00	14·19	172·50	155·25	82·65	3·95
17	1035·8	211·48	4·00	0·50	465·10	75·00	13 33	172 50	155·25	89·84	3 95
18	966·7	196·68	4·00	0·50	465·10	65·62	9·63	172·50	155·25	78·60	3·95
19	870·0	177·62	4·00	0·50	465·10	78·13	11·82	172·50	155·25	98·58	3·95
20	760·0	155·16	4·00	0·50	465·10	33·13	3·80	172·50	155·25	38·98	3·95
				Fan discharging Air at a Density of THREE Ounces per square Inch.								
21	983·3	200·70	3·00	0·38	348·86	82·68	10·15	150·00	135·00	86·00	2·94
22	855·0	174·50	3·00	0·38	348·86	102·72	10·61	150·00	135·00	117·10	2·94
23	773·3	157·80	3·00	0·38	348·86	89·63	7·56	150·00	135·00	93·33	2·94
24	659·2	134·50	3·00	0·38	348·86	56·25	2·98	150·00	135·00	58·50	2·94
				Fan discharging Air at a Density from TWO to ONE Ounce per square Inch.								
25	786·7	160·50	2·00	0·25	232·50	151·60	9·10	122·00	109·80	128·40	1·98
26	676·6	138·15	2·00	0·25	232·50	124·13	5·89	122·00	109·80	107·24	1·98
27	760·0	155·16	1·00	0·13	116·28	264·90	9·38	86·26	77·63	158·60	0·98
28	676·6	138·15	1·00	0·13	116·28	264·90	7·27	86·26	77·63	158·60	0·98
				Fan discharging Air at various Densities.								
29	1166·7	238·10	8·75	1·09	1016·81	13·75	11·94	254·75	229·27	24·32	8 62
30	1160·0	236·80	8·50	1·06	987·97	16·25	11·90	251·20	226.08	28·34	8·40
31	1140·0	232·70	8·00	1·00	930·30	22·50	12·36	244·00	219·60	38·12	7·91
32	855·0	174·50	2·40	0·30	279·09	126·30	10·61	133·60	120·24	117·10	2·36

* These figures in the first six experiments are merely inserted to show the Velocity due to the Density of the Air; and to allow of a comparison being made with the real Velocity of the Tips of the Vanes, without having recourse to calculations.

Note.—In calculating the cubic quantity of Air discharged per second, (as shewn in column 11.) no allowance has been made for the friction of the Air against the sides of the pipes and apertures.

homogeneous column of air equivalent to any given density, as i shown by the table (column 12). Here the velocity has been take as obtained from the laws of falling bodies (as in column 9), to fin the centrifugal force or density of the air. To do this, apply th following rule.

Having given the velocity of the air and the diameter of the fan to ascertain the centrifugal force:—

Rule.—Divide the velocity in feet per second by 4·01, and agai divide the square of the quotient by the diameter of the fan in feet This last quotient multiplied by 1·209, the weight in ounces of cubic foot of air at 60° Fahrenheit, is equal to the centrifugal forc in ounces per square foot, which divided by 144 is equal to th density of the air in ounces per square inch.

Thus if D be the density of the air in ounces per square inch, V the velocity of the tips of the vanes in feet per second, and d th diameter of the fan in feet:—

$$D = \left(\frac{V}{4 \cdot 01}\right)^2 \times \frac{1 \cdot 209}{d} \times \frac{1}{144}$$

Or the following formula may be substituted:—

$$D = NV \times \cdot 0000273$$

where D is the density of the air in ounces per square inch, N the number of revolutions of the fan per minute, and V the velocity of the tips of the vanes in feet per second.*

---

* The two formulæ for D given above are obtained as follows:—

Taking the centrifugal force of a cubic foot of air at the tips of the vanes considered as a solid body,

$$D = \frac{v^2}{r} \times \frac{w}{g} \times \frac{1}{144}$$

where D = pressure or density of air in ounces per square inch, v = velocity of tips of vanes in feet per second, r = radius of fan in feet, w = weight in ounces of 1 cubic foot of air = 1·209, and g = force of gravity = 32·2;

$$\text{therefore } D = \frac{v^2}{r} \times \frac{1 \cdot 209}{32 \cdot 2} \times \frac{1}{144}$$

or if d be the diameter of the fan in feet, then $d = 2r$, and

$$D = \frac{v^2}{d} \times \frac{1 \cdot 209}{16 \cdot 1} \times \frac{1}{144}$$

$$\text{or } D = \left(\frac{v}{4 \cdot 01}\right)^2 \times \frac{1 \cdot 209}{d} \times \frac{1}{144}$$

which agrees with the first of the two formulæ.

Let us now examine the results of the table, considering first the velocity of the tips of the vanes, and the power necessary to drive the fan. In experiments, Nos. 1, 2, 3, 4, 5, and 6, we find by inspecting the table the velocities 236·80, 220·80, 204·16, 185·28, 171·50, and 144·10 respectively, and the corresponding densities of the air are 9·40, 7·90, 6·90, 5·60, 4·50, and 3·50 ounces per square inch respectively. The fan, it must be understood, is discharging no air, but its velocity is merely keeping the air at a certain density or pressure per square inch. Under these circumstances, it requires a certain velocity of the tips of the vanes to maintain a certain density of air, but not in a simple ratio.

The law which governs the velocity of the tips of the vanes appears from these experiments to be that the tips of the vanes should move with $\frac{9}{10}$ths of the velocity a body would acquire in falling the height of a homogeneous column of air equivalent to the density. The latter has been called in the table the theoretical velocity, and by comparing Nos. 1, 2, 3, 4, 5, and 6 experiments as above, the velocity of the tips of the vanes will be found to agree pretty nearly with $\frac{9}{10}$ths of the theoretical velocity. Thus, if the velocity of the tips of the vanes be represented by 1·000, then $\frac{9}{10}$ths of the theoretical velocity will be represented by

	1·005	in No.	1	experiment,
	·986	„	2	„
	·999	„	3	„
	·992	„	4	„
	·960	„	5	„
	1·007	„	6	„
The mean......	·992			

But it will be found not only that $\frac{9}{10}$ths of the theoretical velocity is the most effective speed when the fan is not discharging air, but that the same proportion holds good also when the outlet pipe is open; that is, that the maximum effect of the fan is when the vanes move wi[th]

Also if n be the number of revolutions of the fan per minute, $n = \frac{v}{\ }$ 1·11

and as before, $D = \frac{v^2}{d} \times \frac{1·209}{16·1} \times \frac{1}{144}$; ...our conclusion, that the

therefore $D = \frac{v \times 60}{d \times 3·1416} \times v \times \frac{3·1416}{60} \times \frac{1·209}{16·1} \times$ ...oretical velocity and the

or $D = nv \times ·0000273$, which is the second of ...ly equal. It is evident also

velocity ranging from the theoretical velocity due to the density of the air to $\frac{9}{10}$ths of that velocity, the greatest quantity of air being discharged by the fan under these conditions with the least expenditure of power. To illustrate this more fully, let us refer to the table of experiments, and for our examples we will take Nos. 9, 10, and 11; here the density in each case is 6 ounces.

In No. 10 experiment the velocity of the tips of the vanes is 213·30 feet per second, while the theoretical velocity is 211·30 feet per second, being nearly the same. The quantity of air discharged is 77·91 cubic feet per second, and the power employed in this case amounts to 12·54 horse power.

In No. 11 experiment the velocity of the tips of the vanes is 192·20 feet per second, and $\frac{9}{10}$ths of the theoretical velocity 190·17 feet per second. Now, in these two experiments the results are in proportion to each other nearly; in No. 11 the quantity of air discharged amounts to 35·71 cubic feet per second, and takes 6·43 horse power, while in No. 10 the discharge is 77·91 cubic feet per second, and takes 12·54 horse power. Thus the discharge of air is nearly 2 to 1, and the horse power employed in the same proportion.

In No. 9 experiment the velocity of the tips of the vanes is 221·80 feet per second, being 10 feet per second more than the theoretical velocity; the cubic feet discharged per second being 71·50, and the power 13·81 horse power. Now, if we compare this with No. 10 experiment, we shall find that the velocity is 10 feet per second more, and the cubic feet discharged 6 less, and the horse power 1·3 more.

In the following examples we shall call the theoretical velocity per second unity, beginning with No. 15 experiment. In this example, and similarly afterwards, we shall also call the quantity of air discharged in cubic feet per second unity, and also the horse power. The density of the air in the four following experiments is ounces per square inch :—

If *d* be the ...

No.	Theoretical Velocity.	Velocity of tips of vanes.	Quantity discharged.	Horse power.
	1·00	0·91	1·00	1·00
	00	1·01	2·34	1·93
	00	1·10	2·90	2·88
	0	1·15	2·67	3·16

which agrees with the first of the two for.

In the five following experiments the density is 4 ounces per square inch :—

No.	Theoretical Velocity.	Velocity of tips of vanes.	Quantity discharged.	Horse power.
20	1·00	0·90	1·00	1·00
19	1·00	1·03	2·40	3·42
18	1·00	1·13	2·02	2·89
17	1·00	1·23	2·30	4·04
16	1·00	1·28	2·12	4·27

In the three following experiments the density is 6 ounces per square inch :—

No.	Theoretical Velocity.	Velocity of tips of vanes.	Quantity discharged.	Horse power.
11	1·00	0·91	1·00	1·00
10	1·00	1·01	2·18	1·95
9	1·00	1·05	2·00	2·15

In the four following experiments the density is 3 ounces per square inch :—

No.	Theoretical Velocity.	Velocity of tips of vanes.	Quantity discharged.	Horse power.
24	1·00	0·90	1·00	1·00
23	1·00	1·05	1·59	2·53
22	1·00	1·16	2·00	3·56
21	1·00	1·34	1·47	3·40

To give further illustration of this part of our subject, we will take Nos. 7, 9, 12, and 16 experiments. Here the velocity of the tips of the vanes is the same, and will therefore be denoted by unity. The corresponding densities being 7, 6, 5, and 4 ounces, we shall call the highest unity, as also with the quantity discharged, and the horse power.

No.	Theoretical Velocity.	Velocity of tips of vanes.	Quantity discharged.	Density.	Horse power.
7	1·03	1·00	1·00	1·00	1·00
9	0·95	1·00	1·20	0·86	1·03
12	0·87	1·00	1·35	0·71	1·06
16	0·78	1·00	1·40	0·57	1·11

Nearly all the preceding examples justify our conclusion, that the greatest results are obtained when the theoretical velocity and the velocity of the tips of the vanes are nearly equal. It is evident also

that if we increase the velocity of the tips of the vanes, and only double the cubic quantity of air delivered, it must take more than double the expenditure of power, the density of the air remaining the same.

We shall now give examples of the data dictated by our table of experiments. And first, having given the density of the air, to determine the velocity of the tips of the vanes; also the horse power requisite to drive the fan under these circumstances, the fan not discharging air, but its velocity merely keeping the air at a certain density.

Let D denote the density of the air in ounces per square inch, and A the height in inches of a column of mercury equivalent to that density. Then by the laws of falling bodies (see page 5), $\sqrt{(A \times 930{\cdot}3 \times 64)} = N =$ the velocity acquired by a body falling the height of a column of air of the corresponding density.

Then $\frac{38 \times D}{16} = P$ the number of pounds acting on the vanes;

and $\frac{\frac{9}{10}\text{ths of } V \times 60 \times P}{33000} = HP$ the horse power required.

The constant number 38 is the result of experiment, and has been obtained by inserting the ascertained values of the horse power, &c., in the following formulæ, which are the converse of the preceding:—

$$\frac{HP \times 33000}{\frac{9}{10}\text{th of } V \times 60} = P, \text{ and then } \frac{P \times 16}{D} = 38.$$

Example.—Let $D = 9{\cdot}40$ ounces per square inch; then $A = 1{\cdot}175$ inches of mercury (see page 5); to determine the velocity of the tips of the vanes, and also the horse power.

Here $\sqrt{(1{\cdot}175 \times 930{\cdot}3 \times 64)} = 264{\cdot}4 = V =$ the theoretical velocity, $\frac{9}{10}$ths of which $= 237{\cdot}96 =$ the velocity of the tips of the vanes in feet per second. Then $\frac{38 \times 9{\cdot}40}{16} = 22{\cdot}32 = P =$ the pounds acting on the vanes of the fan. And $\frac{237{\cdot}96 \times 60 \times 22{\cdot}32}{33000} = 9{\cdot}6 = HP =$ the horse power required.

Having given the velocity of the air in feet per second (or, as it has been termed, the theoretical velocity), to determine the density of the air in accordance with the laws of centrifugal force.

Example.—Let the velocity be 264·4 feet per second, and the diameter of the fan 3·9 feet. Then, by a former rule (see page 8) we have $\frac{264\cdot4}{4\cdot01} = 65\cdot9$ and $\frac{65\cdot9^2}{3\cdot9} = 1113\cdot6$ and $\frac{1113\cdot6 \times 1\cdot209}{144} = 9\cdot34$ ounces per square inch = the density required.

Or, by the second rule, the number of revolutions per minute = $\frac{\text{velocity} \times 60}{\text{circumference}} = \frac{264\cdot4 \times 60}{3\cdot9 \times 3\cdot1416} = 1294\cdot8 = N$; and $NV \times \cdot0000273$ $= 1294\cdot8 \times 264\cdot4 \times \cdot0000273 = 9\cdot34$ ounces per square inch, as before.

To determine the horse power necessary to drive the fan when discharging air, the velocity of the tips of the vanes not exceeding $\frac{9}{10}$ths of the theoretical velocity; having given the density of air required, and the quantity to be discharged per minute.

It must here be remarked that according to the table of experiments, when the tips of the vanes move at $\frac{9}{10}$ths of the theoretical velocity, not more than 480 pounds of air are discharged per minute; but this is without any attenuation in the density.

First, find the horse power, as in the previous example, when the fan is not discharging air.

Secondly, multiply the weight of air in pounds to be discharged by the fan per minute by $\frac{9}{10}$ths of the theoretical velocity in feet per second, and divide by 33000. The quotient will give the horse power necessary to discharge this quantity of air, which add to the horse power necessary to drive the fan when not discharging air, for the answer required.

Example.—Let D be the density of air required = 4·00 ounces per square inch; then A = the height in inches of a column of mercury equal to the density = ·5 (see page 5); and let the weight of air to be discharged per minute = 220 pounds.

Here $\sqrt{(\cdot5 \times 930\cdot3 \times 64)} = 172\cdot5$ = the theoretical velocity, $\frac{9}{10}$ths of which = 155·25 = the velocity of the tips of the vanes in feet per second. Then $\frac{38 \times 4\cdot00}{16} = 9\cdot5 = P$ = the pounds acting on the vanes of the fan. And $\frac{155\cdot25 \times 60 \times 9\cdot5}{33\cdot000} = 2\text{-}67$ horse power necessary to drive the fan without efflux.

Secondly, $\frac{220 \times 155{\cdot}25}{33000} = 1{\cdot}00$ horse power necessary to discharge the given weight of air.

Then $1{\cdot}00 \times 2{\cdot}67 = 3{\cdot}67 =$ the total horse power required.

If the quantity of air to be discharged per minute be given in cubic feet, these must be converted into pounds before the above rules can be applied. Thus, let the quantity to be discharged be 2864 cubic feet per minute, at a density of 4·00 ounces per square inch. Now, a cubic foot of common air at 60° Fahrenheit weighs 1·209 ounces, therefore a cubic foot of the given density will weigh 1·229 ounces, and therefore the weight of 2864 cubic feet is 3520 ounces = 220 pounds.

When the velocity of the tips of the vanes is to be equal to the theoretical velocity, then we proceed as in the last example, taking the weight of air in pounds to be discharged by the fan per minute.

It should here be again remarked that when the fan is moving at this velocity, it is capable of discharging 480 pounds of air per minute without any falling off in density.

In a recent set of experiments the inlet openings in the sides of the fan chest were contracted from 17½ inches, the original diameter, to 12 and 6 inches diameter, when the following results were obtained:—

First, the power expended with the opening contracted to 12 inches diameter was as 2½ to 1 compared with that expended with the opening of 17½ inches diameter; the velocity of the fan being nearly the same, as also the quantity and density of air delivered.

Second, the power expended with the opening contracted to 6 inches diameter was as 2½ to 1 compared with that expended with the opening of 17½ inches diameter; the velocity of the fan being nearly the same, and also the area of the efflux pipe, but the density of the air decreased one fourth.

These experiments show that the inlet openings must be made of sufficient size, that the air may have a free and uninterrupted passage to the vanes of the fan, for if we impede this passage we do so at the expense of power.

In conclusion, time alone prevents a further investigation of this subject, but the writer hopes to return to it at no distant period, and generalize the facts gleaned from experiments.

Soho, April 26, 1847.

EXPERIMENTS ON THE FAN BLAST.

[SUPPLEMENTARY PAPER.]

In resuming the subject of the Fan Blast, I shall endeavour, as far as I conveniently can, to avoid detailed statements of the pneumatic laws involved in its consideration, as they would occupy more time than would be consistent with the present occasion; and shall proceed to remark on the most important points connected with the construction of the fan, namely, the forms and proportions which will ensure the best results, with the least expenditure of power, and will effect a diminution of the intolerable noise that generally arises from the working of the fan. And although I have not been able to carry out such leading principles to the fullest extent, I trust that I have furnished materials that will be found of value to those members whose greater leisure may enable them to do so.

From an examination of the action and apparent effect of that very useful apparatus, the blowing fan, it would appear that the air in the fan case is impelled by the vanes along the delivery pipe or channel to the chest provided for the blast; and that the continuous rapid motion of the vanes compresses the air in the pipe and chest, to a degree that may be shown and accurately measured by a water or mercurial gauge attached to the blast chest.

In the former paper the principal investigation rested on the theoretical question, whether the tips of the vanes should partake of the same velocity as a body falling freely from a certain height, the height being governed by the density of air required. Recent experiments, the results of which accompany this paper, justify the conclusions then made, as will be seen on examining tables Nos. 2, 3, and 4.

Having satisfied myself with respect to the velocity a fan ought to have, when a certain density of air is required, I propose in this paper to examine the fan under other conditions, the object being to establish the best proportions of the inlet openings in the sides of the fan chest, and the suitable corresponding length of the vanes. For this purpose,

I caused the openings in the sides of the fan chest to be made of a large diameter, and I was enabled to vary these openings, by fitting in rings of wood; and I varied the fan by attaching to its arms vanes of corresponding lengths. The experiments are classed in the tables appended :—

Table No. 1, Contains the original set of experiments given in the former paper.

„ „ 2, Experiments made with an inlet opening 30 inches diameter, the length of the vanes being reduced to 8 inches.

„ „ 3, With an inlet opening 24⅜ inches diameter, the length of the vanes being 11 inches.

„ „ 4, With an inlet opening 20⅛ inches diameter, the length of the vanes being 13⅜ inches.

„ „ 1 *a*, Shows the effect produced by narrowing the vanes to 6 inches, the length being 16 inches, with outlet to delivery pipe 4 inches deep.

„ „ 2 *a*, 3 *a*, and 4 *a*, Are experiments showing the effect produced by contracting the outlet opening; the inlet opening and the length of vanes being the same as in the table under which they are classed.

In the concluding part of the former paper it was stated that by impeding the free admission of air to the vanes a loss of power was occasioned. Thus, by contracting the inlet opening to 12 inches diameter, more than twice the power was expended. This led to an extension of the openings, the results of which will be seen on comparing the former state of the fan, as shown in table No. 1, with the present state, as shown in tables Nos. 2, 3, and 4.

In the first five experiments, no efflux of air takes place; and if, in these experiments, we take the means of the density of the air and of the horse power, and call them unity, their proportions to the means of the corresponding experiments in tables 2, 3, and 4, will stand thus :—

No. of Table.	Density of Air.	Horse power.
1	1·00	1·00
2	0·69	1·21
3	0·80	0·90
4	1·00	1·10

Here the results are in favour of the fan in its original shape, and similar results appear when the fan is discharging air.

I will now proceed to consider the diameter of the inlet opening, and the best length of vane.

From the experiments given in the tables it will be seen that the longer vane possesses a preponderating advantage over the shorter one, in condensing air of the greatest density, with the least proportion of power. Thus, with a vane 14 inches long, the tips of which revolve at the rate of 236·8 feet per second, the air is condensed to 9·4 ounces per square inch above the pressure of the atmosphere, with a power of 9·6 horse power; but a vane 8 inches long, the diameter of the tips being the same, and having therefore the same velocity, condenses the air to 6 ounces per square inch only, and takes 12 horse power. Thus, the density in the latter case is little more than ·6 of that in the former, while the power absorbed is nearly 1·25 to 1. Although the velocity of the tips of the vanes is the same in each case, the velocity of the heels of the vanes is very different; for whilst the tips of the vanes in each case move at the rate of 236·80 feet per second, the heels of the 14 inch vanes move at the rate of 90·80 feet per second, and the heels of the 8 inch move at the rate of 151·75 feet per second; or, the velocity of the heel of the 14 inch is in the ratio of 1 to 1·67 compared with the velocity of the heel of the 8 inch vane. The longer vane approaching nearer the centre strikes the air with less velocity, and allows it to enter on the vane with greater freedom, and with considerably less force than the shorter one. The inference is that the short vane must take more power, at the same time that it accumulates a less quantity of air.

These experiments lead me to conclude that the length of the vane demands as much consideration as the proper diameter of the inlet opening. If there were no other object in view, it would be useless making the vanes of the fan of a greater width than the inlet opening can freely supply.* On the proportion of the length and width of the vane, and the diameter of the inlet opening, rest the three most important points, namely, the *quantity* and *density* of the air, and the expenditure of *power*.

In the 14 inch vane the tip has a velocity 2·60 times greater than the heel; or, by the laws of centrifugal force, the air will have 2·60 times the density at the tip of the vane that it has at the heel. The air cannot enter on the heel with more than atmospheric density, but, in its passage along the vanes, it becomes compressed in proportion

* The proportion a suction pipe bears to a pump is an analogous case; for if we drive the bucket at a greater velocity than the suction pipe will supply it with water, the consequence will be that we shall not lift so much water, at the same time that we absorb more power.

to its centrifugal force. The greater the length of vane, the greater will be the difference between the centrifugal force at the heel and the tip of the vane; consequently, the greater the density of the air.

Reasoning, then, from these experiments, I recommend for easy reference the following proportions for the construction of the fan:—

Let the width of the vanes be one-fourth of the diameter of the fan.

Let the length of the vanes be one-fourth of the diameter of the fan.

Let the diameter of the inlet openings in the sides of the fan chest be one-half the diameter of the fan.

In adopting this mode of construction, the area of the inlet openings in the sides of the fan chest will be the same as the circumference of the heel of the vane multiplied by its width; or the same area as the space described by the heel of the vane.

The following table gives the sizes of fans varying from 3 to 6 feet diameter:—

Diameter of Fan.		Width of Vane.		Length of Vane.		Diameter of Inlet Opening.	
Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.
3	0	0	9	0	9	1	6
3	6	0	10½	0	10½	1	9
4	0	1	0	1	0	2	0
4	6	1	1½	1	1½	2	3
5	0	1	3	1	3	2	6
6	0	1	6	1	6	3	0

I recommend the proportions in the above table for densities ranging from 3 to 6 ounces per square inch; and for higher densities, from 6 to 9 or more ounces, the sizes given in the following table:—

Diameter of Fan.		Width of Vane.		Length of Vane.		Diameter of Inlet Opening.	
Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.
3	0	0	7	1	0	1	0
3	6	0	8½	1	1½	1	3
4	0	0	9½	1	3½	1	6
4	6	0	10½	1	4½	1	9
5	0	1	0	1	6	2	0
6	0	1	2	1	10	2	4

The dimensions in the above tables are not laid down as prescribed limits, but as approximations obtained from the best results in practice.

In some cases, two fans fixed on one spindle would be found preferable to one wide one, as by such an arrangement twice the area of inlet opening is obtained compared with a single wide fan; and they may be so constructed, where occasionally only half the quantity of air is required, that one of them may be disengaged by a clutch, and thus a saving of power effected. In a single fan of great width, the inlet opening must either be made too small in proportion to the width of the vane, or if it be made large enough for the width of the vane, the length of the vane becomes so short as to be quite incapable of furnishing air of the required density.

It has been stated that the air from the fan chest is impelled by the vanes along the delivery pipe to the blast chest: I beg attention to the results of experiments very recently made by me, with reference to the admission of air into the delivery pipe, which, I think, may lead to an important improvement in the fan. The experiments alluded to were made to enable me to ascertain the result of varying the area of admission to the delivery pipe, in proportion to the quantity of blast required for use; and I effected this by adapting a segmental slide to the circular chest of the fan, as shown in the accompanying drawing, by means of which I varied the depth of the opening into the delivery pipe from 12 to 4 inches.

The object of this arrangement was to diminish the delivery pipe opening at pleasure, in proportion to the quantity of air required, and thereby to lessen the power necessary to work the fan. The results will be seen by the experiments in tables 1 *a*, 2 *a*, 3 *a*, and 4 *a*. The inlet opening to the delivery pipe having been contracted from 12 inches to 4 inches deep, so that the tips of the vanes and the top of the outlet opening were nearly in a direct horizontal line, nearly the same quantity of air was impelled as with the original opening; the noise produced by the fan had however nearly ceased. It therefore appears, that the less this opening is made, provided we produce sufficient blast, the less noise will proceed from the fan; and by making the top of this opening level with the tips of the vanes the column of air has little or no reaction on the vanes.

With respect to the degree of eccentricity which the fan should have with reference to the fan chest, $\frac{1}{10}$th of the diameter of the fan

has been found in practice to answer well; that is, the space between the fan and the chest should increase from $\frac{3}{8}$ths of an inch at the top of the outlet to the delivery pipe, to $\frac{1}{10}$th of the diameter of the fan at the bottom at a point perpendicularly under the centre. The tunnel or main pipe from the fan chest may, for short distances varying from 50 to 100 feet in length, be made not less than $1\frac{1}{4}$ times the area of the delivery pipe in the fan chest; and for distances varying from 100 to 200 feet in length, $1\frac{1}{2}$ times the area of the delivery pipe. The length of a tunnel may be continued to 300 or more feet, provided it be made of sufficient dimensions to allow the air to pass freely along it. The experiments accompanying this paper were made with a tunnel 18 inches diameter and 160 feet in length, and no difference could be detected in the density of the air, when the gauge was applied at any part of the tunnel.

Having investigated the leading characteristics of the fan, it may not be out of place to give a few hints respecting its mechanical construction.

First,—it is one of the greatest essentials that all parts maintain a just and proper balance.

Second,—The arms of the fan should be as light as is consistent with safety. Round arms are decidedly objectionable; I have known instances when their centrifugal force has torn them from the centre boss. I prefer the rectangular arm, having about the proportion of $2\frac{1}{2}$ times the width for the depth at the centre, with sufficient taper towards the tips.

Third,—the bearings and journals of the fan spindle should be made of a length not less than 4 times the diameter of the necks of the spindle.

Finally,—the driving pulleys should be made as large as circumstances will admit of, so that the strap may have sufficient surface to prevent slipping.

The fan from which my experiments were collected was made with these proportions. It has been at work nine years without any perceptible wear.

The application of the fan has hitherto been chiefly limited to smithies and foundries; and in but few instances has it been applied to the smelting of iron ore. I am aware that differences of opinion

exist as to the applicability of the fan to that purpose, the principal reason urged against it being the limited density to which the blast can be compressed by the fan, compared with the blast supplied by the cylinder. It remains however to be proved, whether such high densities are absolutely necessary for the smelting of iron ore; whether we may not produce as good iron by a diffused soft blast, as by the strong and generally applied concentrated blast. I hope it will not be thought presumptuous on my part, thus to doubt long established practices. The old maxim of "there's no way like the old way," is not always based on unerring principles.

As I have before stated, the density of blast afforded by the fan is limited to the force arising from the centrifugal motion of the air in passing along the vanes of the fan; the quantity not exceeding what is due to its velocity and magnitude. But may not this density be increased by using a succession of fans so constructed and arranged that the air may be passed successively through each; the air from the first fan being made to enter the second; the air from the second to enter the third; and the blast finally emitted of adequate density?

I cannot here enter into a further investigation of this important subject; nor are the limits and character of this paper suited to the minutiæ connected with the principles and practice of a smelting furnace; but I hope that the observations which I have made, and the principles I have endeavoured to enunciate, will be the means of instituting further enquiry; and as the expense of constructing a fan can be no barrier, I trust that a fair trial will be made, where convenience is suited to its application for smelting purposes.

Soho, October 23, 1847.

			No. 4.				
	Origin...er, and Vanes di... ...ide.		With an Inlet Opening 20½ inches diameter, and Vanes 13⅝ inches long, by 10⅝ inches wide.				
No. of Experiments.	...of ...rge ...e ...are ...s.	Indicated Horse Power.	Number of Revolutions of Fan per Minute.	Velocity of Tips of Vanes in Feet per Second.	Density of Air in Ounces per square Inch.	Area of Discharge Pipe in square Inches.	Indicated Horse Power.
No. 1		...	...	...	...	...	...
„ 2		6·10	1081·7	220·80	7·70	0	8·40
„ 3		5·96	1000·0	204·16	6·70	0	7·84
„ 4		4·13	900·0	183·74	5·50	0	5·20
„ 5		3·90	786·7	160·50	4·40	0	4·45
„ 8		...	1063·3	217·09	7·00	25·00	10·70
„ 10		...	1063·3	217·09	6·00	42·50	11·47
„ 11		...	966·7	196·68	6·00	35·00	10·07
„ 12		...	...	...	...	...	...
„ 14	...ↄ	7·30	966·7	196·68	5·00	65·00	14·04
„ 15		...	878·5	179·10	5·00	37·50	7·30
„ 16	...]	...	...	...	...	...	...
„ 17	...)	7·00	...	...	...	...	...
„ 18	...)	8·90	983·3	200·70	4·00	79·60	12·70
„ 19	...)	6·17	870·0	177·62	4·00	66·00	9·90
„ 20		...	773·3	157·80	4·00	35·00	5·70
	...)	8·70	...	...	...	...	...
„ 21	...)	7·29	...	...	...	...	...
„ 22	...)	7·80	870·0	177·62	3·00	103·60	10·70
„ 23	...)	6·76	786·7	160·50	3·00	97·10	10·42
			No. 4, *a*.				
With the Outle... Inlet Opening 1...	... inches deep.		With the Outlet Opening contracted to 4 inches deep. NO EFFLUX.				
		2·75	885·0	180·70	5·50	0	3·70
			WITH EFFLUX.				
	...5	2·40	900·0	183·74	4·00	40·00	6·90
	...ches deep.		With the original Outlet Opening, 12 inches deep. NO EFFLUX.				
	...8	3·46	885·0	180·70	5·50	0	4·31
			WITH EFFLUX.				
	...5	3·98	885·0	180·70	4·00	60·70	9·30

INSTITUTION

OF

MECHANICAL ENGINEERS.

DESCRIPTION

OF AN

IMPROVED SUSPENSION BRIDGE,

FOR

CARRYING A RAILWAY, AND FOR OTHER PURPOSES.

BY

EDWARD A. COWPER.

PAPER READ AT THE MEETING AT BIRMINGHAM,

27TH OCTOBER,

1847.

PUBLISHED BY THE INSTITUTION.

DESCRIPTION OF AN IMPROVED SUSPENSION BRIDGE, FOR CARRYING A RAILWAY, AND FOR OTHER PURPOSES.

By Mr. EDWARD A. COWPER, of Birmingham.

The object of the present Paper is to call the attention of engineers and railway directors generally to a mode which I have invented of constructing Suspension Bridges in such a way, that they shall not *be thrown out of shape* or in *any way distorted* by the weight of a passing load, whether it consists of a railway train, or only of the ordinary traffic of a common road.

It is well known that Suspension Bridges are decidedly less costly than any stone bridges, and I may add than most iron bridges, when the span is at all above the length of an ordinary girder; and although many persons have directed their attention to them, particularly with regard to their use on railways, I am not aware that any suspension bridge has ever been made, or proposed, that was at all competent to carry the weight of a railway train in motion, or in other words, that should be safe as a railway bridge.

My attention was particularly called to Suspension Bridges, by the proposal of carrying a railway over the Hungerford Bridge, or over a bridge placed close alongside of it; and it appeared to me that the weight of a passing train would so move and distort the chains, as to cause the road very soon to get out of order, if not actually to give way, and I then devised the plan of making a chain of such depth as to include any alteration in the *curve of the strain* that might take place.

The curve which the chains of an ordinary Suspension Bridge take is well known to be a catenary, or rather a curve between a catenary and a parabola. It would be a true parabola if all the weight were in the platform, and a true catenary if all the weight were in the chain. As however the difference between the catenary and the parabola is very slight indeed, in that portion which would be used for a bridge, we may assume it to be a catenary for all practical purposes.

Now on loading an ordinary Suspension Bridge with even a small weight, it at once assumes a different curve (unless the weight be equally distributed over the bridge), and if the weight be large, it will assume a very different curve; so much indeed will the form be altered, as to injure or strain the material of which the platform or road is composed. Now it is evident that if the road has to *distribute* the weight, it must be a very strong and stiff beam, or in fact a girder of the full length of the bridge; and the strength of this girder would very nearly be equal to carrying a quarter of the weight of the load in the centre; it is therefore evident that the plan of forming a stiff platform or road for a railway suspension bridge, although by no means impossible, must be at least half abandoning the suspension principle, and be the cause of greater outlay.

The plan of keeping the road in shape by distributing any weight that might come upon it, by means of strong diagonal ties,

was the first idea that occurred; but it will be found by calculation that these diagonals would have to be very strong, and of considerable height, thereby causing the total depth of the bridge to be much greater.

But the plan on which I propose to construct Suspension Bridges, capable of carrying railway trains without being in any way injured thereby, is simply to make the chain of such depth as to include the curve of strain, when the weight is placed upon the bridge in the most unfavourable positions. With this object I construct the chains of boiler plate of considerable depth, (say 3 or 4 feet or more,) and rivet the whole well together, without any moveable joints or separate links, and at the top and bottom edges of the chains I rivet or otherwise attach bars, either flat, half-round, or angle-iron, so as to give an accumulation of metal at those parts, and, at the same time, to render the edges of the chains perfectly secure against any tendency to rip or tear.

In the accompanying Drawing, you will observe that there are two chains, each four feet deep, which support the ends of cross wrought-iron girders (in the position of sleepers), each chain being composed of four boiler plates, riveted together in pairs, each plate being $\frac{3}{8}$ of an inch thick, and at the top and bottom edges there are securely riveted strong angle-irons. The suspension bars hang between the two pairs of plates forming the chain, and are supported by a small saddle, which bears on the top edges of them. The ends of the cross wrought-iron girders are firmly secured to a light rib of boiler plate, which runs along each side of the bridge, as shown in the cross section of the bridge; the lower ends of the suspension bars are secured to the ends of the girders, with means of adjustment, so that the road may be trimmed perfectly level when the bridge is fixed. There are also light diagonal ties introduced for the purpose of more perfectly staying the road to the chains, particularly in case of the breaks being applied whilst a train is passing over the bridge.

The rails, either of the ordinary form placed in chairs, or of that form commonly called the bridge rail, are supported on balks of timber scarphed together, which run longitudinally throughout the bridge, and these are supported by short balks of timber running from girder to girder, immediately under the first. There are a series of diagonal ties placed in the platform, as shewn in plan in the drawing; these act as a means of stiffening the platform, and preventing any vibration or shaking of the parts. Stay rods also are provided, by which the bridge is prevented from moving or swinging sideways; they are attached to the piers, and are very similar to some used by Mr. Brunel, senr., in a bridge at the Isle of Bourbon.

The Drawing is of a Bridge 200 feet span, having the cross girders 8 feet from centre to centre, and the chains 4 feet deep, which depth has been arrived at by actual experiment. The weight of the road for one line of rails and one chain, is 1 ton per foot run; and the weight of a train of locomotives I have assumed at 1 ton per foot run, (and this is allowing some margin for the continued growth of locomotives) and I have taken as a proof load 2 tons per foot run; thus the weight of the load, or disturbing cause, will be just double the weight of the bridge.

I find the greatest distortion of the *curve of strain* takes place when the bridge is only half loaded, (*i. e.*) from one end to the centre; the curve then approaches the bottom of the chain, very nearly in the centre of the loaded half, and approaches the top of the chain in the centre of the unloaded half; whilst at the piers it approaches the top at the loaded end, and the bottom at the unloaded end. Again, if the same load be placed in the centre of the bridge, (covering one-half of the length) the curve of strain will approach the bottom of the chain in the centre, and will approach the top of the chain at very nearly one-fifth from each pier, whilst at the piers it will be near the centre of the chain, but rather above it.

Take one more case, and we shall have disposed of all the heavy disturbing tendencies, viz.: that of the ends loaded and the centre left unloaded, the curve of strain will then approach the top of the chain in the centre, and the bottom of the chain at about one-sixth from each pier; whilst at the piers the strain will be slightly above the centre. I may add, that when the bridge is fully loaded throughout, the curve of strain is in the centre of the chain throughout its length.

I propose to call bridges made on this plan "INVERTED ARCH BRIDGES."

(Signed,)

E. A. COWPER.

Birmingham, October, 1847.

INSTITUTION

OF

MECHANICAL ENGINEERS.

DESCRIPTION

OF THE

LUGGAGE ENGINE "ATLAS."

BY

CHARLES F. BEYER.

PAPER READ AT THE MEETING AT BIRMINGHAM,

24TH NOVEMBER,

1847.

PUBLISHED BY THE INSTITUTION.

DESCRIPTION OF THE LUGGAGE ENGINE "ATLAS."

By Mr. CHARLES F. BEYER, of Manchester.

The present communication does not pretend to lay before the Institution any peculiar novelties, but is simply confined to the description of the particular construction adopted by the makers, for this class of engine.

The Engine here to be described belongs to the class called inside-cylinder engines; has inside framings and six wheels, all of them coupled.

Its dimensions are as follows:—

18 inch cylinders, with 2 feet stroke.

Boiler 3 feet 6 inches diameter, by 13 feet 6 inches in length, containing 175 brass tubes, of $1\frac{5}{8}$ inches outside diameter; and 4 feet 6 inches wheels, made of cast iron.

The copper firebox is 3 feet 8 inches long by 3 feet $3\frac{1}{4}$ inches wide inside, and measuring 3 feet $4\frac{1}{2}$ inches from the top of the firebars to the underside of the roof.

The water spaces round the four sides are 3 inches, and that of the midfeather running across the box is 4 inches in width.

The weight of the engine in working condition is 24 exactly.

The order for these engines was given on the 14th Nove 1844, and the dimensions at that time were thought large; hov the size of locomotives has been so much and so rapidly incr since, that they no doubt will appear much dwindled down at distant period. Still the performances accomplished with ther nevertheless thought to be deserving of some attention, havi the best knowledge of the writer not been excelled either b or since.

Sheet I. represents a side elevation; Sheet II. a longitu section; and Sheet III. different cross sections.

Sheet IV. shows the engine in plan, and represents details o cylinders, connecting and coupling rods, the force pump, and s regulator, on an enlarged scale of 3 inches to the foot,—the ge plans being half that size, or 1½ inch to the foot.

The framing A consists of two single flat plates, 1 inc thickness, to which the cast-iron slides for the axle bearings riveted sideways.

A truss or stay B is introduced between the front and ce wheels, to relieve the forks from the strain between the piston crank shaft.

The fastening of the two frames to the body of the engin made at the front by means of the smokebox sides C C; and boiler and firebox are made to slide or expand upon them, by me of mortice holes in the boiler-feet D and E, and angle pieces which form the connection with them.

The draw-plates G G are fastened to the two frame-plates o without having any connection whatever with the firebox.

The cylinders are secured to each other by internal flanches; they form the bottom of the smokebox, and the principal cross stay between the two frames, to resist buffing.

The valves are inclined towards each other, situated in one chest, and, being placed below the cylinders, afford a direct exhaust to the chimney.

The weight of the valves is carried by their spindles, made to work through stuffing-boxes in both the loose end-lids. H, a cross stretcher, forged in one piece, firmly bolted to the frames A A, but unconnected with the boiler, to carry the hind ends of the steel slides I I I I and reversing shaft J, receives the front ends of the force pump, and prevents the eccentric rods M M from falling to the ground in case of breakage.

The valve spindles N, being below the front axle and not tending to the centre of the crank, a kind of pendulum lever O is introduced, for rectifying the angles, and to form the connection between the valve links and the block P, which the expansion link Q acts upon.

The steam regulator R (see Sheet IV.) is in this instance made with a second disc S, provided with two small holes T, each about $1\frac{1}{8}$ inches area, which, being acted upon first on turning the regulator handle, admits steam into the pipes and cylinders, and thus removes the pressure from the ordinary disc U before it is moved, and enables the driver, without any particular attention, to start as gradually as he pleases.

Sheets V. and VI. are diagrams of the working of the valves for a complete revolution of the wheel when going forward, taken from a full-size model.

The curves 1, 2, 3, 4, and 5, of the admission and exhaustion of the steam correspond to a traverse of the valve of $4\frac{13}{16}$, $4\frac{1}{16}$, $3\frac{5}{16}$, $2\frac{3}{4}$, and $2\frac{3}{16}$ inches.

Although one engine, the "Atlas," has been here described, it will be necessary to state, for the better understanding of the particulars connected with their working, which the writer has succeeded in collecting, that Messrs. Sharp Brothers and Co. have made six of these engines, varying only in the number and diameter of their tubes, but in other respects perfect duplicates of each other, namely:—for the Manchester and Sheffield Railway four engines, called

ATLAS,
HERCULES,
HECTOR,
JUPITER;

and two engines, Nos. 30 and 32, for the Manchester and Birmingham Railway, the last of which has been transferred since to the London and Birmingham Railway. The difference of the tube plates above referred to, and the heating surfaces and flue-areas of all the six engines, are given in full upon Sheet VII.

The engine "Atlas" was put to work on the Manchester and Sheffield Railway in May 1846, and ran up to the 31st of October last 40,222 miles in all; her consumption of coke being 37·94 lbs. per mile. For further particulars see Table II. in the appendix.

Sheet VIII. shows the wear of the tyres (Low Moor) in two opposite places of each of the left-hand wheels of the "Atlas," after running the above distance of 40,222 miles.

A table of the gradients and curves of the Manchester and Sheffield Railway is given in the appendix.

To try the capabilities of one of these engines, a train of 101 wagons, weighing 597 tons, was prepared by Mr. Salt, the Goods Manager of the Manchester and Birmingham Railway, on Saturday, the 3rd of October, 1846, for the engine No. 30 to take from Longsight to Crewe, a distance of 29 miles, and it was accomplished at an average speed of 13·7 miles per hour.

A section of that portion of the London and North Western Railway is given upon Sheet IX. The working of the train on *this* occasion was as follows:—

Put the steam on at Longsight	9 12	a.m.
Passed the mouth of tunnel at Stockport .	9 41	"
" Macclesfield Junction	9 49	"
" Handforth Station	10 1	"
" Wilmslow Station	10 10	"
Came to a dead stop at Alderley	10 16	"
Sent the engine forward to Chelford to take in water, and		
Put on the steam again at Alderley . . .	10 54	"
Passed Chelford Station	11 8	"
" Holmeschapel Station	11 28	"
" Sandbach Station	11 41	"
" Rookery Bridge	11 44½	"
Arrived at Crewe	11 57	"

The size of blast-pipe for running the above trip was 3¼ inches diameter, or 8·3 square inches.

Since the transfer of the engine No. 32 to the London and Birmingham Railway, I have received only one monthly statement respecting her performance, namely for June last. During that month she ran 3,004 miles, with a consumption of coke of 0·214 lbs. per ton per mile; the next best engine then at work on that line burning 0·38 lbs. per ton per mile.

APPENDIX.

TABLE I.

MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY.

TABLE OF CURVES.

Distance from Ardwick to end of Curve.		Length of Curve.	Radius of Curve.	Side towards which Curve bends.
Miles.	Chains.	Chains.	Chains.	
0	11	11	13	North.
0	62	51	straight.	...
0	76½	14½	60	South.
1	0	3½	straight.	...
1	9	9	80	S.
1	44½	35½	straight.	...
1	68	23½	80	N.
2	0	12	60	N.
2	22	22	straight.	...
2	34	12	100	S.
2	69	35	straight.	...
3	9	20	80	N.
3	17	8	straight.	...
3	53	36	120	S.
3	65	12	straight.	...
3	70	5	80	S.
4	30	40	straight.	...
4	43	13	80	S.
4	48	5	straight.	...

TABLE OF CURVES—CONTINUED.

Distance from Ardwick to end of Curve. Miles.	Chains.	Length of Curve. Chains.	Radius of Curve. Chains.	Side towards which Curve bends.
4	79	31	80	S.
5	11	12	straight.	...
5	50	39	80	S.
6	1	31	80	N.
6	24	23	straight.	...
6	41½	17½	60	N.
6	50	8½	straight.	...
6	75	25	70	N.
7	18	23	straight.	...
7	33	15	17	S.
7	54	21	70	N.
8	1	27	straight.	...
8	7	6	80	N.
8	39	32	straight.	...
8	46	7	120	N.
8	60	14	40	N.
9	15	35	straight.	...
9	19	4	30	S.
9	27	8	straight.	...
9	32½	5½	30	N.
9	40	7½	straight.	...
9	63	23	40	N.
9	74	11	160	N.
10	3	9	60	N.
10	19	16	60	S.
10	37	18	straight.	...
10	72	35	40	N.
11	4	12	straight.	...
11	31	27	40	N.
11	78	47	58	S.
12	77	79	straight.	...
13	23	26	40	S.
13	53	30	40	N.
13	73	20	40	S.
14	11	18	straight.	...
14	33	22	60	S.
14	72	39	straight.	...
15	16	24	40	N.

TABLE OF CURVES—CONTINUED.

Distance from Ardwick to end of Curve.		Length of Curve.	Radius of Curve.	Side towards w Curve be
Miles.	Chains.	Chains.	Chains.	
15	45	29	60	N.
16	3	38	60	S.
16	24	21	40	N.
16	69	45	45	S.
17	6	17	40	N.
17	42	36	straight.	...
17	60	18	60	S.
18	7	27	160	N.
18 ...	25	18	straight.	...
18	35	10	40	N.
21	38	243	straight.	...
21 ..	66	28	40	N.
22	2	16	36	N.
22	33	31	straight.	...
22	50	17	40	S.
22	70	20	90	N.
23 ...	16	26	110	N.
23	22	6	120	N.
23 ...	45	23	70	S.
23	74	29	80	N.
24 ...	36	42	38	S.
25	4	48	40	N.
25	36	32	40	S.
25	72	36	40	N.
26	20	28	straight.	...
26	42	22	40	S.
27	20	58	straight.	...
27	67	47	50	S.
28	20	33	50	N.
28	53	33	55	S.
30 ...	12	119	straight.	...
30	61	49	80	N.
31	17	36	40	S.
31	77	60	60	S.
32 ..	41	44	straight.	...
33	14	53	60	N.
33 ...	56	42	straight.	...
34	6	30	80	S.

TABLE OF CURVES—CONTINUED.

Distance from Ardwick to end of Curve.		Length of Curve.	Radius of Curve.	Side towards which Curve bends.
Miles.	Chains.	Chains.	Chains.	
34	30	24	80	N.
34	51	21	40	S.
35	15	44	30	N.
35	59	44	35	S.
36	7	28	40	N.
36	42	35	straight.	...
36	73	31	40	N.
37	59	66	straight.	...
37	68	9	40	S.
38	25	37	straight.	...
38	44	19	35	N.
39	2	38	35	S.
39	50	48	40	N.
40	15	45	straight.	...
40	19	4	40	S.
40	24	5	straight.	...

Total length, 3224 chains; or 40 miles, 24 chains.

MANCHESTER, SHEFFIELI

LUGGAGE EN

FROM MAY

Period of Working.	Miles run. Coach Trains.	Goods Trains.	Piloting.	Total.	Engineer's and Fireman's Wages. £	s.	d.	Coke consumed, Total. Weight. Cwts.	Cost. £	s.	d.	Oil. £	s.	d.	Tallo £	s.
May to June 1846	...	..	...	2,800	11	11	4	903	31	3	10	5	5	0	1	16
to Dec. 1846 ...	100	17,175	105	17,380	84	10	8	5,773	203	19	0½	26	6	0½	9	17
to June 1847...	...	12,664	26	12,690	72	2	8	4,535	151	3	4	27	13	8	8	2
to Oct. 1847 ...	...	7,352	...	7,352	39	4	4	2,414	100	4	2	12	18	4½	4	16
Totals ...	100	37,191	131	40,222	207	9	0	13,625	486	10	4½	72	3	1	24	13

II.

LINCOLNSHIRE RAILWAY.

"ATLAS," No. 26,

31st OCTOBER 1847.

Sundry Stores.	Material for Repairs.	Wages for Repairs.	Repairs not done by Co.	Cost of Tender. Material for Repairs.	Cost of Tender. Wages for Repairs.	Total Cost.	Coke consumed per mile run.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	Lbs.
16 11 11	0 0 0	0 16 11	0 0 0	0 0 0	0 0 0	68 10 7	36·12
4 9 2	0 19 0	8 2 10	0 9 2	5 7 1	0 2 8	350 16 8½	37·20
26 10 7	10 0 1	44 7 5½	51 5 8	6 15 7	3 10 4½	409 10 10	40·08
14 10 7	1 19 6½	17 0 4	27 1 0	0 5 6	0 2 0	221 18 8½	36·77
62 2 3	12 18 7½	70 7 6½	78 15 5	12 8 2	3 15 0½	1050 16 10	37·94

TABLE III.

MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY.

LIST OF GRADIENTS.

Locality where change of gradient occurs.	Distances. Total.	Distances. Length of Gradient.	Levels. Rise.	Levels. Fall.	Gradients. Per mile.	Gradients. Rate.	Height above low water at Liverpool.
	Miles Ch.	Ml. Ch.	Feet.	Feet.	Feet.		Feet.
Manchester & Birming-	0 14·0	0 14·0	0·00	...	0·0	level	169·56
ham Railway Station	0 58·0	0 44·0	7·50	...	14·0	1 in 337	177·06
Chancery Lane . .	0 60·0	0 2·0	0·69	...	11·0	1 in 480	177·75
Blind Lane	0 4·0	0 4·0	0·41	...	11·0	1 in 480	178·16
Stockport Canal . .	1 75·5	1 71·5	56·92	...	30·0	1 in 176	235·08
Gorton Reservoirs . .	2 60·0	0 64·5	42·58	...	52·8	1 in 100	277·66
North Street	3 70·0	1 10·0	45·00	...	40·0	1 in 132	322·66
Guide Bridge . . .	4 20·0	0 30·0	6·00	...	16·0	1 in 330	328·66
Near River Tame . .	4 40·0	0 20·0	0·00	...	0·0	level	328·66
Dukinfield Road . .	4 63·6	0 23·6	8·76	...	30·0	1 in 176	337·42
Newton Wood Colliery	5 60·0	0 76·4	50·58	...	52·8	1 in 100	388·00
Newton Green . . .	6 56·5	0 76·5	26·77	...	28·0	1 in 188	414·77
Hattersley	8 16·5	1 40·0	56·40	...	37·6	1 in 140	471·17
Broadbottom . . .	9 26·0	1 9·5	11·63	...	10·4	1 in 511	482·80
Gamsley	10 47·0	1 21·0	55·65	...	44·0	1 in 120	538·45
Dinting	11 7·0	0 40·0	0·00	...	0·0	level	538·45
Deepclough	13 31·0	2 24·0	121·44	...	52·8	1 in 100	659·89
Woodhead, entrance to Summit Tunnel .	18 37·0	5 6·0	227·35	...	44·8	1 in 118	887·24
Summit Level . . .	21 38·0	3 1·0	79·20	...	26·4	1 in 200	966·44
Dunford Bridge . .	21 47·0	0 9·0	...	1·44	12·8	1 in 410	965·00
Ranah	24 30·0	2 63·0	...	111·50	40·0	1 in 132	853·50
Hielands	25 40·0	1 10·0	...	49·50	44·0	1 in 120	804·00
Penistone	27 15·0	1 55·0	...	67·50	40·0	1 in 132	736·50
Penistone T. P. Road .	27 22·3	0 7·3	...	0·00	0·0	level	736·50
Poorhouse Lane . .	28 0·0	0 57·7	...	38·10	52·8	1 in 100	698·40
Road at Oxspring . .	29 0·0	1 0·0	...	32·80	32·8	1 in 161	665·60
Road from Wortley to Thurgolam . . .	30 70·0	1 70·0	...	75·00	40·0	1 in 132	590·60
Oughty Bridge . . .	35 62·0	4 72·0	...	215·60	44·0	1 in 120	375·00
Sheffield Station . .	40 24·0	4 42·0	...	181·00	40·0	1 in 132	194·00
Totals	40 24·0	40 24·0	788·69	772·44			

INSTITUTION

OF

MECHANICAL ENGINEERS.

DESCRIPTION

OF THE

MULTIFARIOUS PERFORATING MACHINE.

BY

BENJAMIN FOTHERGILL.

PAPER READ AT THE MEETING AT BIRMINGHAM,

26TH JANUARY,

1848.

PUBLISHED BY THE INSTITUTION.

DESCRIPTION OF THE MULTIFARIOUS PERFORATING MACHINE.

BY MR. BENJAMIN FOTHERGILL, OF MANCHESTER.

THE accompanying drawings illustrate the details of an improved Machine for Perforating such Metal Plates as are used to form ships, steam boilers, girders, tubular bridges, and other strong works made of metal plates, with a row of holes equal in number to or fewer than the punches in the machine, which holes may be of the same or of different sizes, and at the same or different distances apart. A series of rows of such holes may be made in each plate, and any of the punches may be prevented from acting at pleasure.

In Sheet I., Fig. 1 represents a front elevation, Fig. 2 a side elevation, and Fig. 3 a horizontal section, taken through the dotted line *A A* in Figs. 1 and 2, of an improved Perforating Machine for making holes in strong plates. Fig. 4 is a detached view of the traverse apparatus; and Fig. 5 a detached view of the holding-down or stripping apparatus. In Sheet II., Fig. 6 represents a sectional elevation of the machine shown in Sheet I.; Fig. 7 an elevation of the back of the machine; Fig. 8 a plan view of the apparatus for putting the punches out of action, without stopping the flywheel; and Fig. 9 a plan view of a few of the Jacquard plates. *A A* the standards.—*B* the bed, through which there is an opening for the punchings, or metal punched out of the plate, to fall; this bed is inserted into the standards.—*C* a stretcher bar, to connect the top of the standards.—*D* a fulcrum bar of the levers *q q*, which withdraw the punches, and of the lever *w*, which traverses the plate.—*E* a fulcrum

shaft, to which the levers *j j* and *k k* are keyed.—*F* the main or eccentric shaft, working in bushes in the standards.—*G* a spur wheel keyed on the eccentric shaft.—*H* a pinion, working into the wheel *G*.—*I* the flywheel shaft, on which are the fast and loose pulleys *K* and *L*, the pinion *H*, and the flywheel *J*.—*M M* connecting rods, fitted to the eccentric necks of the shaft *F*.—*N N* caps of the connecting rods *M M*.—*O O* guide plates for the punch rams *P P*.—*Q* the cam shaft.—*R* a spur wheel, loose on the cam shaft, and having on one side two projections, between which there is an opening.—*R** a locking disc or plate, keyed on the shaft *Q*, having upon it a spring catch 38, which takes into the opening between the projections on the wheel *R*.—*R* and *R** are seen detached on Sheet II., and the dotted lines on *R** represent a weight to counterbalance the levers *K*.—*S* a toothed wheel, keyed on the main shaft *F*.—*T* the punch ram depresser, secured to the connecting rods *M M* by knuckle joints at the lower end of the connecting rods.—*U* a slide-bar on which the frame traverses which carries the plate to be punched.—*V V* two short slide-bars, to carry one side of the traverse frame.—*W* a block of iron fastened with short wedges to the bed *B*, to carry the die plate *X*, into which the dies *d* are inserted, and prevented from rising by a collar at the lower end of each, as seen in Fig. 5.—*Y* a square shaft, carrying the holding-down levers, or stripping fingers *o o*.—*Z Z* levers on each end of the shaft *Y*.—*a a* the punches let into the punch-holders *b b*, bolted to the rams *P*, as seen in the detached views on Sheet II.—*c c* pieces bolted to the bed *B*, to carry the adjusting slide-bars *V V*.—*d* dies inserted into the holder *X*.—*e e* (see Fig. 6) are the selecting slide-bars, which, when allowed to pass through the card plate, enter the card roller *f*, without being pushed backward by the plate; the card roller has in this case six sides, and the belt of Jacquard plates, after passing over it in the usual manner, travels over a round roller suspended in a swing frame at such an angle as shall keep the belt moderately tight, whilst the roller *f* advances towards and recedes from the selecters *e*.—*g g* brackets projecting from the depresser *T*, and carried up and down with *h h* its sliding blocks, in which the journals of the card-roller turn.

To an upright cast on each of these blocks is fitted a rod of round iron *, with a flat foot long enough to extend over two of the six pins in the end of the card roller, against which the flat foot of the rods is made to press by spiral springs coiled around them in the usual manner employed in the Jacquard loom, which being generally known need not be further described.

i i (see Fig. 6) are two sets of guide blocks for the selecters *e*, one on each side of the depresser, adjustable laterally by set screws on flat bars *O* extending across the machine. The use of these blocks is to carry the selecting bars *e*, which are round at the end which enters the cards, and flat at the other end, to keep them in their proper positions; the centre portion of each selecting bar is a solid piece of iron projecting as much below the round stem as will, when the selecting bar is driven backwards by a card plate, permit the depresser *T* to complete its downward stroke without the selecting bar touching the ram *P* under it.

j j are levers keyed on the shaft *E*, and connected at their lower ends by links to the slide-blocks *h h*.—*k k* also are levers keyed on the shaft *E*, and having each a friction roller at its lower extremity. On the shaft *Q* are two cams, one of which works the lever *k* on one side of the shaft, and the other cam works the other lever *k* on the opposite side. One of the cams, through the medium of the levers *j j* and the links before referred to, causes the roller *f* to approach the selecting bars *e*, and the other cam causes the roller to recede from them, until, by a catch employed in the ordinary way in the Jacquard looms, the roller *f* is made to turn through one sixth of a revolution, and is then retained in that position by the pressure of the spiral spring and flat foot above referred to.

l l are brackets attached to the depresser *T* at the back of the machine, seen best in Fig. 6.—*m* a bar resting on the brackets *l l*, and connected by rods with the sliding blocks *h h*, which on receding cause the bar *m* to bring all the selecting bars *e* into the position for depressing the rams, as seen in Fig. 6.—*n n* are levers having their

fulcra on studs screwed into the standards; one end of these levers is connected by a rod *p* with the levers *Z Z*; the other end is furnished with a roller which is acted upon by a cam *u* on the shaft *Q*, see Fig. 2.—*o o* are the holding-down levers, adjustable laterally on the shaft *Y*, so as to admit of one of them being placed on each side of every punch.—*p p* are rods connecting the levers *n* and *Z*. By adjusting the length of these rods the levers *o o* are made to press upon plates of different thicknesses, so as to hold the plates down while the punches are being withdrawn.—*q q* levers turning on the fulcrum bar *D*, for withdrawing the punches by means of the cams *r r* that actuate the levers *q q*.—*s* a broad but rather thin bar, extending through the series of punch rams *P*, shown by dotted lines in Figs. 1 and 7.

The punch rams *P* are made with slots, through which the bar *s* passes, and these slots must be about two inches longer than the width of the bar *s*, in order to allow the punch rams to be forced down when the bar is at the bottom of its stroke.—*t t* are links connecting the bar *s* with the levers *q q*.—*u u* are cams which depress the holding-down levers *o o*, through the medium of the levers *n n*, rods *p p*, and levers *Z Z*, and hold down the plate while the punches are being withdrawn.—*v* a cam for the traversing rack 5.—*w* a lever turning on the fulcrum bar *D*, and worked by the cam *v*.—*x* the cam for lifting the rack 5.—*y* a lever turning on a stud in the standard, and worked by the cam *x*, for lifting the traversing rack 5.—*z* a rod connecting the lever *y* with the lever 8, seen best in Fig. 4.

1 is a lever on the traverse shaft 2.—3 another lever on the shaft 2.—4 a link connecting the lever 3 with the rack 5.—6 a rod connecting the lever *w* with the lever 1, for traversing the rack 5.—7 a shaft for carrying the levers 8, 9, and 10.—11 a link connecting the levers 10 and 12.—13 a shaft carrying the levers 12 and 14.—15 and 16 are links connecting the rack 5 with the levers 9 and 14.—17 the upper or retaining rack.—18 a stud carrying the elbow lever 19, which is provided with a handle.—20 another stud carrying the elbow lever 21, which is connected by a link 22 with the lever 19:

the rack 17 is carried on studs, in the horizontal arm of the levers 19 and 21.—23 division studs in the bar 24 of the traversing frame.

The plate to be punched is put into a traversing frame, formed of two side bars 24 and 25, and two stretcher bars secured by cotters to the side bars, which are rabbeted to support the plate, and, when required, furnished with clamps to hold the plate down.—24 represents one of the sides of the traversing frame, in which there is a groove to fit on the slide-bar *U*; into the outer side of the bar 24 is screwed a series of studs 23, represented in the drawing as being 12 inches from centre to centre apart from each other; the side 25 of the frame slides on the bars *V V*. When the plates to be punched are very long, rollers may be used to carry the projecting ends of the traversing frame.

In Fig. 3 is shown part of a frame, with a plate partly perforated. The racks 5 and 17 (see Fig. 4) are drawn with three teeth in the length of a foot, which will divide plates to a 4 inch pitch; but it will be obvious that for a different pitch the racks must be changed, and it may in some cases, such as when the pitch required is not an aliquot part of a foot, be necessary to alter the distance between the studs 23.

Fig. 4 represents the traverse apparatus in the position it will be in when the retaining rack is down, and the punches in the act of passing through the plate, the traversing rack having completed its return stroke. When the punches are being raised, the traversing rack will rise also; and by the side piece 26, which is attached to it, acting against the roller 27 on a stud in the rack 17, will raise it also, and set the frame at liberty to be advanced by the cam *x*, through the mechanical means already described. In Fig. 6 this traverse apparatus is shown in the position it assumes when the plate is advancing. The spiral spring 28 acts on the lever 21, and forces the rack 17 down on to the pins 23.

For every hole required to be punched in line with the width of the plate under operation, a corresponding hole must be made in a plate of the Jacquard; and an additional hole, marked 30, (see Fig. 9,) is also made, into which the stopping bar 31 enters at every stroke until the punching be completed; at which time the Jacquard plate 32, which is left blank, will push all the selecting bars *e* beyond the rams *P*, and at the same time, by pushing the bar 31, disengage the cam shaft *Q*, by the mechanism to be hereafter explained, at the point where the punches and the levers *o* are held up, and thus will allow the perforated plate to be taken out of the machine, and another plate to be put into it. A lateral motion may be given to the plate which is being perforated by this machine, in the same manner as is hereinafter described in the machine for perforating thin plates of metal. The stopping bar 31 is provided with a projection on its lower surface, which depresses the click lever 39, when the bar is pushed back; the lever 33 is keyed on a shaft 34, moving on bearings at the back of the depresser; on the other end of the shaft 34 is keyed the lever 35, to the upper end of which is attached the link 36, connecting it with the elbow lever 37. The end of the other arm of this lever is inclined, for the purpose of unlocking the plate *R**, and is provided with a stud, on which is a latch 38, the tail of which comes in contact with the incline on the elbow lever 37, when it is in the position shown by dotted lines in Fig. 8; and as the wheel *R* revolves, the latch becomes disengaged from the opening between the two projections cast on the said wheel, at which time the cam shaft *Q* ceases to revolve. When the stopping bar 31 has been pushed back, it depresses the lever 39, and liberates the lever 33 from behind the projection on the lever 39, when the spring 40 will pull the elbow lever 37 into the position shown by the dotted lines.

To the blocks *h* a small shaft is attached, on which are two levers, suspending by links a plate of metal similar to a blank card plate, except that the holes for the guide pins are cut at the bottom edge. At each end of the same shaft is a lever handle, held up or down by a side spring in the ordinary way. The use of this

apparatus is as follows :—should it be required to stop the machine before the plate is finished, by raising the lever here referred to, the blank plate will come in front of the roller, and will act the part of a blank Jacquard plate, and stop the machine.

Having now described the principal parts of this machine, I shall proceed to explain the manner of its working. The plate to be punched, having been placed in the traversing frame, on the slides *U* and *V*, is then pushed forward. In its progress, the first pin of the series 23 passes under the inclined end of the rack 17, until the first notch in the rack falls upon the pin. The driving strap being now on the fast pulley *K*, the machine is set to work by pulling down the handle 42, keyed on the shaft 34, until the lever 33 is latched by the click lever 39; the elbow lever 37 is then, by the spiral spring 40, brought into the position shown in Fig. 8; the latch 38, being now liberated, will, by the action of the spring 41, (see Fig. 6,) drop into the notch in the wheel *R*, the first time it comes round; the cam shaft *Q* will now revolve at the same speed as the shaft *F*, and the Jacquard roller *f* will be drawn back, and made to perform one-sixth of a revolution on its centres, after which it will be advanced, and the first card of the series will remove those selecting bars for which there are no holes in the Jacquard plate; the other selecting bars will remain over their respective rams *P*, which will then force down the punches through the plate, by the descent of the depresser *T*. A little before the punches have gone through the plate under operation, the levers *o* are made to press upon it, and are held there while the punches are being withdrawn by the bar *s*, which rises simultaneously with the depresser *T* during one-half of its ascent. Whilst the depresser is continuing its ascent and descent through the other half of the stroke, the roller *f* recedes, and draws with it the bar *m*, which brings all the selectors again over the punch rams *P*. The roller *f*, while receding, having performed another sixth of a revolution, will, on advancing, bring another of the Jacquard plates against the selectors, and the operation will be repeated until all the holes are punched in the plate under operation.

AN IMPROVED MACHINE FOR PERFORATING THIN SHEETS OF METAL, AND PUNCHING METAL SURFACES, SO AS THEREBY TO FORM VARIOUS DEVICES OR PATTERNS.

Many parts and movements in this machine are almost identically the same as in the machine for punching and perforating strong or thick plates, previously described, and it will be consequently quite unnecessary to notice them here. Of this class are the standards, the eccentric shaft and connecting rods, the driving shaft, fast and loose pulleys, cams and levers, cam shaft, and toothed wheels.

In Sheet III., Fig. 10 represents a vertical section of the machine, taken at right angles to the row of punches. *A A* is the bed, which differs from that already described, principally in being made of two flat plates of cast iron, bolted against pieces of iron *B*, which regulate the distance between the plates, instead of being cast in one piece; or the pieces *B* may be cast on one, or partly on both plates.—*C* one of many pieces of steel, accurately fitted to each other, and to the angular recess in one side of the bed, and made fast to the other side (over which they project, for the convenience in handling,) by the screw *D*. Each of the pieces *C* is perforated, in reference to the other pieces, in such manner that when the pieces are put in their places, the row of holes in the series shall be such as may be required; but, for the sake of perspicuity, we shall consider the holes in this instance to be in a straight line, and all of the same size; and to avoid repetition shall premise, what must be evident to any one acquainted with the subject, that the number and distance of the holes in each row will be the same as the number and distance of the punches, wire springs, and guide wires.

E an iron casting, secured at its ends to a flanch on each end of the standards, in such manner as will admit of its being readily withdrawn, to enable the punches, the dies, and the other parts of the machine hid by it, to be examined.—*F* the punch guide fastened by screws to *E*, which also serves as the stripper off, by holding down the plate whilst the punches *H* are being withdrawn by the flanch at the bottom of the bar *G* lifting against the underside of the heads of the punches; the flanch at the top of *G* is to strengthen it.—*J* the punch rams, kept in the vertical position by pieces of thin flat wire, made fast in the dovetailed grooves *K K* by pouring soft metal when in a molten state into them, in the manner usually practised in similar cases by stocking and lace machine makers. The piece *G* is held against the piece *E* by vertical slide pieces at its end.—*I* one of the series of wire springs in the lower flanch of the piece *G*, to keep the series of rams *J* vertical.—*L* is the depressing bar, extending across the machine, and moving in vertical slides in the standards.—*M* is a tempered steel bar, let into a groove in the bar *L*, and held there by bolts.—*N* is a plate of brass, extending across the machine, and screwed in the bar *L*.—*O* is another plate of brass extending across the machine, which is also screwed to the bar *L*.—*P* is a selecting block, of which there is a series, corresponding in number with the punches. In each end of this a round wire is fixed, one marked *Q*, and the other *R*. The wires *Q* and *R* work in holes in the plates *N* and *O*, of which there is a number corresponding with that of the punches.

The bent wire spring *S* is inserted by an elbow end into a hole in *O*, and the other end through a hole in the block *P*, into both of which holes it enters easily. Its office is twofold, namely to press the block *P* in the direction of the arrow, and to keep it in its proper position in reference to the bars *M* and rams *J*.—*T* is a four-sided prism, turning on bearings attached to *L*, over which perforated cards or card plates are made to pass in chain, after the well-known manner of the Jacquard for weaving figured fabrics. The prism *T* is represented in the drawing as having a groove on each side, extending throughout its whole length, instead of a number of holes

corresponding to the number of wire needles or selectors in the ordinary way. The groove prism will suit cards of various pitches or degrees of fineness.

In this machine the plate to be perforated, marked *U*, is clamped or otherwise secured to a traversing frame, such as is generally used for that purpose, to which the following addition is made, for varying the pitch in reference to the forward motion while the plate is under operation; namely, when a screw is employed to advance the plate, either the collar or the nut in which the screw works is made to slide a little in the direction of the length of the screw, on the piece to which the same is usually attached: this sliding of the nut or collar may be regulated by a cam or eccentric; and the same principle of retarding or accelerating the plate is applied when a rack and pinion are employed.

In addition to the longitudinal traverse, there is given to the plate a lateral motion, which may be regulated by a cam or cams, or by an eccentric or eccentrics, according to the nature of the devices or patterns to be punched or perforated by the machine. To adapt the mechanism for producing such compound movements, the longitudinal sliding frame is made to traverse upon a cross slide, the manner of constructing which, and of communicating motion to the cams, will vary according to the pattern required, and need not be further noticed here, as it will suggest itself to any competent mechanic.

Fig. 12, on the same sheet, shows a different arrangement of mechanism, for putting out of action at each stroke of the machine such punches as are not required to be used. The principal difference consists in the wires *Q*, when pressed by the cards, pushing the punch rams *J*, which move on the punch head as a fulcrum, beyond the reach of the steel depresser *M*. Another slight difference is made in putting the wires *Q*, and thé prism *T*, to move up and down with the piece *G*, instead of with *L*, as shown with reference to Figs. 10 and 11.

It will be obvious, on inspection of the drawings, that two of these machines may be put to face each other on the same standards, and that a greater number, if required, may be put in series; and from what has previously been said respecting the part *E* resting on a flanch on the standards, it will be seen that the parts *E* may be slid out, for inspection and repairs of the punches, &c. As two or more series may be employed at the same time on the same job, and each series of a different size or form to the other or others of them, it follows that by due care in making the designs, and in the adjustments of the mechanism, an immense number of patterns may be produced with the same set of punches.

It will also be apparent that large punches, having *set* patterns, may be used in conjunction with small punches which are under the influence of the Jacquard. Large punches with *set* patterns may also be brought into operation by means of the Jacquard.

In Sheet III. is represented a machine (similar in principle to that just described) adapted to perforate paper and thin sheet metal, such as sieves and window blinds are made of, in which plain perforations arranged in squares may be made by a single row of punches; and perforations arranged quincuncially may also be made with a single row of punches, by giving to the plate a lateral alternating motion; but a double row of punches, arranged intermediately with each other, is preferable. Each of these arrangements admits of a great variety of fancy patterns, by the application of the Jacquard principle.

A large class of patterns may be produced by punches of various forms and sizes which shall be so grouped together as to give to the work a columnar effect. And the range of this class may be extended by giving the plate a zigzag or waved motion; and still further by combining it with the Jacquard.

AN IMPROVED ARRANGEMENT AND COMBINATION OF THE PARTS OF A PUNCHING OR PERFORATING AND SHEARING MACHINE

A combined Punching and Shearing Machine, suitable fo punching and shearing simultaneously plates and bars of metal, i represented in the drawings annexed.

Fig. 13 is a front elevation of the end of the machine to whic the shears are applied.—Fig. 14 is an elevation of the punching en of the machine; and Fig. 15 is a side elevation of the machine showing the shears at one side and the punch at the other.—Fig. 1 is a front elevation, and Fig. 17 a side elevation, of another of th improved modes of driving the combined punching and shearin machine.

In Figs. 13, 14, and 15, *a* represents the frame or standards, t which all the working parts of the machine are attached.—*b* is th driving shaft.—*c* a pinion fixed upon it, and driving the wheel *d* which is keyed on the eccentric shaft *e*.—*k* is the flywheel, on whic are cast clutches, taking into clutches cast on the pinion *c*. Th object of these clutches is to connect the pinion with the flywheel i a more perfect manner than can be done by keying them to th shaft.—*f* represents the eccentric for working the shears, and the eccentric for working the punch, both turned out of the solid o the shaft *e*.—*h* is the sliding plate, to which the upper blade of th shears is secured; and *i* is the connecting rod for working the slid *h* up and down.—*l* is the connecting rod reaching from the eccentri *g* to the projection *m* cast on the plate *n*, to which is attached th punch holder.

The punch slide *n* is lifted up after every stroke by the followin contrivance:—upon the shaft *e* is an eccentric *o*, which acts agains a roller on a pin in one arm of the lever *p*, which turns on a stu

fixed in the standard *a*. The link *s* decends from another arm in the lever *p*, and is connected with the lever *t*, the fulcrum of which is at *t**. The other end passes through a slot in the frame *a*, and takes into an opening provided in the punch slide *n*.

The eccentric *g* produces a stroke of rather more than twice the thickness of the strongest plate to be punched by the machine, but the eccentric *o* causes the punch slide *n* to rise only a little above the thickness of the same, thus giving the person who attends the machine a better opportunity of setting the plate, than if the punch were taken up the whole length of the stroke of the connecting rod *l*. If he should fail to set the plate correctly in due time, he can prevent the punch from descending, by pulling the handle *q* in the direction of the arrow: this motion will remove the connecting rod *l* from its vertical position over the projection *m*, by means of the link *r*, which connects the rod *l* with the short lever projecting from the handle *q*. Upon the same shaft as the handle *q* is fixed a lever and weight *u*, the object of which is to retain the connecting rod *l* in the position it has been placed by the workman. The die and the stripper or holder-down are made in the usual manner.

In Figs. 16 and 17, *A* represents part of a frame or standard of a machine similar in its general construction to that described with reference to Figs. 13, 14, and 15; the only difference being in the method of driving the eccentric shaft *B*, upon which in this instance is fitted a pulley *C*, connected firmly with the flywheel *D* and spur pinion *E*, to work loose on the eccentric shaft. The pinion *E* gears into a wheel *F* keyed on the top shaft *G*, on which is also keyed a pinion *H*, gearing into a wheel *I* keyed on the eccentric shaft *B*. The pinions are to their wheels respectively in the proportion of one to three; consequently the eccentric shaft *B* will make one revolution for nine revolutions of the driving pulley *C*. The proportions between the diameters of the wheels and pinions may be varied to suit the work to be executed by the machine. Machines of this description may be made to punch on both sides or to shear on both sides, instead of punching on one and shearing on the other.

A machine such as is represented in Sheets I. and II. was made for Mr. Evans, the contractor for the iron tubular bridge which is to carry the Chester and Holyhead Railway over the River Conway at the town of that name. This machine is employed to perforate the plates for the bridge, and is at present adapted to punch such pitches only as that work requires, viz., 3 inches and 4 inches from centre to centre of the rivet holes, with latitude for departing considerably from those (general) pitches in the lateral rows of holes. It is constructed to perforate at each stroke a row of holes 3 feet 5 inches broad; but, by employing a series of card plates similar to the cards used in the Jacquard loom, any number of punches may be put out of action at pleasure; and, by means of a blank card at the end of the series, the machine is put out of action at a point where no obstacle is presented to the taking out of the perforated plate, and putting a blank plate in its stead. The operation of changing plates, weighing 6 or 7 cwt. each, is performed by half a dozen men in less than one minute; and whilst one plate is being punched, these men get another ready to put into the machine. As this machine makes 11 to 12 strokes per minute, it follows that with a 4-inch pitch a 12 feet plate may be punched in less than four minutes, and consequently that (allowing one minute for changing) the machine may perforate twelve such plates per hour. Many of the plates in the bridge are 12 feet long, 2 feet 8 inches broad, and $\frac{3}{4}$ inch thick, and are punched for rivets 1 inch in diameter.

As there are but few engineering concerns where such a perforating machine as that at Conway could be employed more than an hour or two per day, it appears to me to be very desirable that ironmasters should have them, and that they should also have machines for straightening and bending plates. By these means they would be enabled to supply their customers with plates in a fit state for being riveted together.

Were this system brought into practice, engineers would direct their attention to adapt their work to the capabilities of the perforating machine; and thus great perfection, despatch, and economy of construction would be the result.

PROCEEDINGS.

April 26, 1848.

The usual General Meeting of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Wednesday, the 26th of April, 1848; George Stephenson, Esq., President, took the chair at five p.m.

The President, in a few remarks, congratulated the members on the prosperous state of the Institution, and expressed the pleasure he felt in meeting so many of the eminent mechanical engineers of England. He would come amongst them as often as he possibly could, for it gave him sincere pleasure to do so. He then called upon the Secretary, Mr. Kintrea, to read the minutes of the previous meeting; which were confirmed.

The President said the first subject that would occupy the attention of the meeting was "On Boring and Fitting up Cylinders for Locomotive Engines;" on which a paper had been read at the last meeting by Mr. Beyer. Mr. Beyer was now unavoidably absent, and Mr. Fothergill had been requested to explain the construction and mode of operation of the machine referred to.

Mr. Fothergill did not consider it necessary to read the paper again; but he entered into a verbal description, referring from time to time to the drawings which accompanied the paper.

Mr. Fenton, of Leeds, considered that the operation was somewhat complex as regarded the chipping of the cylinder, and employing the conical plates.

Mr. McConnell said, I can bear testimony to one part of Mr. Fothergill's statement. About three years ago, one of the engines made by Messrs. Sharp and Co. had a split cylinder, and I wrote down for another to replace it. In three days I had a cylinder sent up, which actually fitted in every particular, so that not a file had to be put upon it; showing the perfect manner in which they were got up.

The President said that the fact stated by Mr. McConnell was very satisfactory; there could be no doubt that the idea was of importance; and the thanks of the Institution were due to Mr. Beyer for his valuable communication.

The Secretary then read the following Paper, by Mr. F. Bashforth, M.A., Fellow of St. John's, Cambridge:—

ON THE FORMATION OF THE TEETH OF THE DRIVERS OF PIN WHEELS.

The proper form of the teeth of wheels is a subject that has long engaged much of the attention of mechanicians; and for many purposes all desirable accuracy has been attained. Still cases occur where the ordinary spur wheels cannot be employed, and various substitutes have been tried on different occasions with more or less success. Professor Willis has shown that the proper form for the teeth of spur wheels is a compound of portions of epicycloids and hypocycloids. He confined his attention to the *proper forms of the teeth*, and to the means of *describing them*. I am not aware that self-acting machinery has been applied to give those forms to metal wheels when mounted on their axes; and until this is accomplished, little can be expected beyond an improvement in the ordinary application of spur wheels.

From the facility with which almost perfect forms may be given by simple self-acting machinery, to the teeth of the drivers of pin wheels, I think this old system worthy of attention. I am not aware that the method employed in the formation of the accompanying cast iron model has ever been previously used, or recommended in any publication; but it has at least the merit of being simple and capable of any degree of accuracy.

It is well known that if the pins be supposed to be mathematical lines, the proper forms of the teeth of the driver will be portions of the epicycloids described by a point in the circumference of the pitch circle of the pin wheel, when caused to roll on the pitch circle of the driver. But suppose the tracer to become a cylinder, with the above mentioned tracing *point* in its axis; the interior edge of the curve so described will be the proper form for the tooth adapted to drive pins of the same diameter as the tracing cylinder.

If the tracer be replaced by a cylindrical cutter, this, as it revolves on its own axis, which is caused to move in the proper epicycloid, will form with accuracy the interval between two teeth of the driver. By turning the wheel to be cut through the proper angle, the interval between the next two teeth will be formed; and so on till the whole is completed.

I propose that the pins should be formed in two parts,—a solid cylinder surrounded by a tube of iron. These might be polished and casehardened. The interior cylinder must be of sufficient strength to withstand the stress of the machinery, and when the tooth of the driver came in contact with the outer case of the pin, this would revolve through a small angle, and thus all abrasion of the teeth of the driver would be avoided.

Although I am fully aware of the difficulty of giving the necessary accuracy to the teeth of metal wheels, when applied to *increase* the angular velocity of an axle, still I think this method might be applied with a reasonable prospect of success to the screws of steamers, and if successful there, to a great variety of other purposes. Wooden teeth of any size could in like manner have accurate forms given to them, but it would perhaps be found difficult to keep them in their places.

Mr. McConnell observed that he did not conceive, from this description by Mr. Bashforth, that his plan of cutting the teeth was anything different from that which was usually employed. Mr. Bashforth might imagine it was new, but he (Mr. McConnell) believed that all pattern makers, or all he had ever seen making wheels, were accustomed to pursue the same method as Mr. Bashforth had described. The form of teeth was decidedly what was used in the old cog and drum corn-mill teeth a century ago. However the gentleman being an amateur deserved credit, for he no doubt had conceived the idea.

Mr. E. A. Cowper said he did not agree with Mr. McConnell: th
had the old trundle and spur wheel in it, but the teeth, if made accor
the description, would be an epicycloid struck by the circle of the pin
and the particular application of the machine was a circular cutter of th
diameter as the pins, which should cut the teeth in the wheel;
the teeth in the wheel were struck by a cutter exactly the diameter
pin which was to work with them, they must be the true shape. It w
only proposition for a machine to cut epicycloid teeth by the opera
the machine itself.

Mr. McConnell stated that in his earlier days they used to stri
all the teeth of the wheel by the teeth of the pinion. The invariabl
of all the mill-wrights in that part of the country was to take the cog
and pinion, and strike out the teeth of the cog wheel from the pitch
the other;—the principal plan of forming the epicycloid.

Mr. Fothergill said there was another method, namely, inst
striking the wheel out with the compasses, in the way to which re
had been made, which was the old plan, to take two blocks, repres
the pitch lines of the two wheels; let these two come in contact on
the other, and have a sheet of tin upon the wheel or the pinion block, a
a projecting point over it from the other block alternately, and le
describe the form of teeth required, so that the one shall describe th
of teeth in the pinion, and the other the form of teeth required
wheel; that being the most true and legitimate principle, so far as he
of striking wheels in use at the present time. He did not see anythin
in the present proposition, but the idea might be original with Mr. Basl
and they ought to give that gentleman credit for it: at the same ti
decidedly considered that they had at the present time much improved
the method now brought before them.

Mr. Buckle thought that a great deal of merit was due to the
of the paper; and he believed the idea suggested might be found
useful. In these remarks the President entirely agreed.

The next Paper was by Mr. Thomas Craddock, of Birmingham :

ON A BOILER AND CONDENSER SUITABLE FOR EXTENDING THE CORNISH ECONOMY AND FOR PREVENTING BOILER EXPLOSIONS.

In submitting to the meeting the subject of this paper, it appears desirable to call attention to the well established practical data, from which, by the Cornish system of generating and using steam, such economical results have been obtained. To this end a very brief review of the various laws or principles immediately bearing upon the subject seems to be essential for placing the matter in its proper light before the meeting. For this purpose perhaps the classified mode is the preferable one.

Firstly, we have to do with the laws by which heat is transmitted from hotter to colder bodies, and *vice versâ*. These demand in the steam boilers and condensers an extensive surface, and, as far as other circumstances will allow, that such surface be composed of thin metal. It is further necessary, if we would produce the greatest economy in the generation of steam, that the heat produced in the furnace be to as great an extent as possible absorbed by the water; this is best effected by a subdivision of the gases, by a slow draught, and by completely surrounding the combustible matter in the furnace by the water in the boiler.

Secondly, the hydrostatic laws require, in order to render high pressure steam equally safe from explosion as low pressure, that we diminish the sectional area of the interior surface of the boiler upon which the pressure of the steam acts, in the same ratio as we increase its pressure. If we do this, then the rending force tending to burst the boiler remains the same at whatever pressure the steam be generated.

Thirdly, the laws relating to latent and sensible heat, when considered in combination with large volumes of water, and subjected to the casualties attending the steam engine, suggest the diminishing the quantity of water necessary in steam boilers, as far as practical circumstances will permit, as one of the surest means of preventing destructive boiler explosions. The importance which attaches to the suggestion these laws present becomes apparent when we consider the effects in case of explosion, which such an amount of sensible heat produces as that contained in the large volume of water necessitated in boilers of 60 horse power, for instance, and of the usual construction; as the sensible heat contained in so large a volume of

water would, supposing the pressure of the steam to diminish from 40 lbs to 20 lbs. per square inch, generate a volume of steam at 20 lbs. pressure equal to 30,000 cubic feet. Here we have a cause equivalent to the diffusive and destructive effects exhibited in common and large boiler explosions. The boiler to which this paper refers reduces the danger from this cause nine tenths, though the steam be generated in it at a temperature and pressure of 100 lbs. per square inch. In this case, we find the sensible heat contained in the water required by such boilers would give but 3000 cubic feet of steam at 20 lbs. pressure. The boiler under consideration is equally successful in diminishing the risk from explosion, arising from the rending strain due to the pressure of the steam; as on a comparison with the common boiler, in which we suppose the steam at only 36 lbs. pressure, we find the rending force to be 5400 lbs., whilst in the tubular, even with 100 lbs. pressure, the rending force amounts to only 900 lbs., or but one sixth of that given in the instance of the common boiler. The most obvious and certain conclusion to which such well established principles lead cannot fail to show how ill-grounded and unscientific must be the objections raised against high pressure steam when generated in such boilers.

Fourthly, the laws relating to the expansive action of steam plainly indicate the importance of the two leading features of the matter before the meeting, namely, that of removing the atmospheric pressure from the exhaust side of the piston, on the one hand, and on the other, enabling us to make use of high pressure steam with safety; as by the removal of the atmosphere in non-condensing engines an economy is produced by this cause alone equal to 38 per cent., and by increasing the pressure of the steam at the commencement we can obtain a further increased economy upon the Cornish system equal to 40 per cent.

My boiler and condenser form part, only, of arrangements which have been practically proved to give the following advantages:—an increased extent of grate surface: a slow rate of combustion: great extent of heating surface for the fire to act upon: increased facility for generating the quantity of steam required: water free from deposit for the use of the boiler: removal of the atmosphere from the exhaust side of the piston: insurance of safety from explosion: great facility for generating the steam under higher pressure, by which the expansive principle is much extended: diminished tendency to priming: an effectual means of preventing the loss arising from steam blowing away at the safety valve: self-adjusting means for

keeping the steam at a uniform pressure, whatever the pressure desired may be: a continuous supply of pure water for the use of the boiler, it not requiring a *fresh* supply of more than one gallon per horse power per day to make good that lost by leakage: the engines and boilers compacted into a much less space, and not half the weight, for equal power, of those in general use.

A small working engine was placed before the meeting.

The PRESIDENT enquired whether there would not be a liability in the top and bottom chambers to give way.

Mr. CRADDOCK replied that he had had these boilers in use for five years, and he had worked them as high as 130 lbs.; but in general from 60 to 80 up to 100 lbs., and he had never detected any leakage whatever.

The PRESIDENT:—You expect a saving of fuel in this, I suppose?

Mr. CRADDOCK:—I do; but I am not at present prepared to submit the exact amount.

The PRESIDENT:—What vacuum do you get?

Mr. CRADDOCK:—I have got from 24 to 26 inches of mercury, and I do not despair of getting 28. I hope to be able very shortly to show an engine of 40 horse power, which shall not take half a horse power to drive the condenser. It will not take so much power to work the air pump on this principle, as by the injection system. I do not propose this as a substitute for water, by any means; but I propose to carry that principle into every place where air can be obtained, so far as other practical circumstances will admit.

The PRESIDENT:—I think it requires a very ingenious mind to follow you.

Mr. McCONNELL enquired if any trial had been made of the engine in actual work.

Mr. CRADDOCK replied that it had been tested at the London Works at Smethwick, and referred to Mr. Cowper of that establishment for the particulars of the trial.

Mr. COWPER:—Mr. Craddock brought the engine to our Works, and, as near as I can remember, the results were,—that the horse power

was 22 and a fraction, indicated horse power; and the condenser took one and a half horse power to drive it. I think it may have been less, but not more, while the engine was doing the work of 22 horse power. The vacuum was 22½, and in a very hot day in August he got as high as 25 inches.

Mr. McConnell:—May I enquire the diameter of the cylinder, the stroke, and the pressure of the steam?

Mr. Cowper:—I think the high pressure cylinder was 7 inches diameter, and the other 13 inches.

Mr. Craddock:—The other was 14 inches. The stroke of the high pressure cylinder was 16 inches, that of the other 2 feet.

Mr. Cowper:—The pressure of steam was generally about 80 lbs.; but that varied.

Mr. Crampton:—I should like to know what proportion the condensing surface bears to the heating surface of the boiler.

Mr. Craddock:—I can furnish you with the substance of it. For instance, in an engine of 10 horse power the condenser would be a weight equal to 10 or 12 cwt. The larger the engine the less would be the proportionate weight; but I can say it would not exceed 12 cwt. for 10 horse power.

Mr. Crampton:—We generally suppose 9 feet of heating surface to generate steam for one horse power; and what I meant was, how many feet of cooling surface would condense this?

Mr. Cowper:—I think it was, as near as possible, 40 square feet to 41. I think Mr. Hall used with his water condenser 20 feet, and Mr. Craddock with his atmospheric condenser used twice as much.

Mr. Craddock:—I use about twice as much surface for giving out the same quantity of heat; but I think I shall be able to show, that I produced treble the amount of power from the same quantity of steam.

The President:—Have you any idea of trying it with locomotive engines as well as stationary?

Mr. Craddock:—That depends upon whether I obtain sufficient encouragement; but I think it would be found highly economical there; and hence I have an idea that some day or other it may be so applied.

Mr. Buckle:—Do I understand that you generate three times the quantity of steam that a common boiler does?

Mr. CRADDOCK:—Certainly not. All I contend for is, that there is a larger amount of surface for the heat to act upon; and I conclude that I get a facility for generating steam which the common system is not capable of.

Mr. McCONNELL:—What is the proportion of the low pressure cylinder to the high pressure?

Mr. CRADDOCK:—Six to one.

Mr. McCONNELL:—And the relative pressure of each when working?

Mr. CRADDOCK:—That will materially depend upon the space which there is between the two cylinders for the steam to expand in. It is a matter of experiment only.

Mr. McCONNELL:—So far as your experience goes, what do you consider to be the relative pressure of the two cylinders?

Mr. CRADDOCK:—As four to one.

Mr. McCONNELL:—Yes, that is the area; but the pressure?

Mr. CRADDOCK:—Experiment will determine that.

Mr. CRAMPTON:—I think he has to expand the steam six times when he has a pressure of 80 lbs. above the atmosphere. Is that so?

Mr. CRADDOCK:—It is not fixed.

Mr. CRAMPTON:—The expansion of steam is only relative. The general rule is, that at a pressure of 25 lbs. the steam is expanded five times. It appears to me that, in asking questions about the relative capacities of the small and large cylinder, we should always bear in mind the pressure of steam to be worked.

The PRESIDENT:—I should like to see the engine pumping water, in order to test it.

Mr. McCONNELL:—What is the relative consumption of your engine?

Mr. CRADDOCK:—I have not carried my experiments so far as to form any rule: but where I derive the economy is chiefly in the expansion of the steam.

Mr. McCONNELL:—I think it is now some four or five years ago, since you first brought it under notice, and I was then anxious to ascertain what its economy was. Now I had hoped that having acquired more experience we should have been favoured with statements upon the subject, and also as to what Mr. Henderson's engine did as compared with yours. They were at work at the same place, and you had every opportunity of making the necessary experiments if you had wished it.

Mr. Craddock :—I have never directly asked Mr. Henderson; but I have many times thrown out a suggestion that it might be satisfactory to have some experiments made, and the suggestion was never acted upon.

Mr. McConnell :—In dealing with this question, we have to trust entirely to practice; and as to the economy of expanding steam to a certain extent, and that particular system of condensation, I do not think we are prepared to give a decided opinion. The best test would be, as the President has stated, that of pumping water.

Mr. Buckle :—Or grinding corn.

The President :—Or driving a locomotive engine.

Mr. Craddock :—I submit whether the indicator is not a sufficiently good test.

Mr. Crampton :—No question of it: but, when talking of economy, we must take into consideration, first, what does the boiler do? how much water do we evaporate for a given surface? When that is settled, then we may ask how much better is it than another? There is a question whether the two cylinders are better than a single one. Evidently a loss there is in the expansion of steam from the small cylinder to the large one, which you never can get back, and which you avoid by using a single cylinder. There may be a little more equal motion, but that is all you get. I tried them some years ago, and I found that you would lose something like 14 per cent., merely in the travelling of the steam from the small cylinder to the large one. It is however desirable that we should come to some settled opinion upon the subject. My impression has always been that there is a loss connected with the small cylinder. Put the same amount of steam in the large cylinder, cut it off, and you will do more work than if you first put it in the small one, and then sent it through to the large one.

The President :—There must be a loss. No doubt the Cornish engine does its work more economically from having only one cylinder.

Mr. Crampton :—What I want to know is, If the double cylinder is so good, *why* is it so? I cannot find by any experiments I have made, that there is any reason for it. There is, as I have said, a rather more uniform motion; and that little advantage I think we can get from a flywheel. We must lose a certain quantity of steam in going through the passage, and the gain of the more uniform motion is more than compensated by the greater economy in having the high pressure steam.

The PRESIDENT:—If you throw the steam into the large cylinder, and cut it off at high pressure, at a short portion of the stroke, you have that steam to expand over the other portion of the cylinder, before it is thrown into the condenser; this brings the high pressure and low pressure systems into action in the same cylinder, and you have as much power in that as you have in two cylinders.

Mr. McCONNELL:—There is one subject which we have not yet considered, and that is the advantage to be gained from using the revolving air-condenser, as compared with the ordinary jet-condenser of a stationary engine. There is certainly the advantage of using the same water and having no sediment, instead of drawing it up by an air pump and discharging it.

Mr. CRADDOCK:—In reply to Mr. Crampton and the other gentlemen, I may state, that the practice of the profession is in my favour, as regards the use of the two cylinders. Time was however when these engines were tried and thrown aside. Let me call the attention of the meeting to the model before us. It is scarcely necessary to remind the members that in so small an engine the friction is considerable when first started; yet it had worked up to its speed with the steam cut off at 1-60th of the stroke; to get the same effect in one cylinder would cause great irregularity of motion. Another thing which I have found in the course of my experience—which has been considerable, having been engaged ten years in this matter, seven of which have been devoted in a great measure to experimenting—is, that those experiments with respect to the relative advantages of the double and single cylinder have proved to me, that by admitting high pressure steam direct from the boiler into the cylinder a considerable portion of it becomes condensed by coming into contact with the comparatively cold metal of such cylinder; the water resulting therefrom being in contact with the metal of the cylinder does, when placed in communication with the condenser, again assume the form of steam, which passing to the condenser uselessly carries away much heat from the boiler to it, without producing mechanical effect. I suggest that a more conclusive test than that of indicator figures, to which Mr. Crampton has alluded, will be that of two cylinders, one of which could be readily thrown out of action; such engine being connected with the same boiler, expanding the steam to the same extent, and performing the same work, the steam and coal required in both cases being accurately weighed. I have made experiments which are

perfectly conclusive to my own mind; and I hope shortly to be able to give you an invitation to investigate experiments which will be equally satisfactory to yours.

Mr. McConnell:—There is more than the question of the two cylinders involved in this. There is another principle, and if Mr. Craddock would pay attention to that, it might afford a great deal of information. I allude to the principle of condensing by air, in contra-distinction to our ordinary way of condensing by a water jet. If there is economy in that, we get this result, that we have pure water; and we all know the benefit of that in the working of a steam engine. I merely suggest this, that Mr. Craddock may bring forward at a future period the results of this principle, as well as the advantages it may afford in the generation of steam. It appears to me that the condenser is most valuable for marine purposes.

Mr. Craddock:—The advantages of the condenser for marine purposes may be stated in a few words,—it would ensure water free from deposit, thus rendering tubular boilers practicable, which enable us to generate high pressure steam with safety; and thus by carrying out the expansive principle, with other advantages consequent thereupon, a saving of two millions annually, in the steam navy alone, would be effected.

Mr. Jackson:—I have for many years looked upon double cylinder engines as compound machines. From the manner in which Mr. Crampton has discussed this matter, it is evident that he could throw some additional light upon it. I therefore beg to move, "that this meeting will esteem it a favour if Mr. Crampton will prepare and lay before the next meeting a paper and diagrams descriptive of the experiments made by him, on the comparative merits of the double and single cylinder systems." The motion having been seconded was carried unanimously.

Mr. Crampton assured the meeting that it would give him great pleasure to do anything he could to elicit information on the subject. He had made some experiments eight or nine years ago, and he would be happy to go into the question again.

The next Paper, by Mr. Peter Rothwell Jackson, of Manchester, was read by Mr. Fothergill:—

ON A HYDRAULIC STARTING APPARATUS.

Various contrivances for connecting heavy machinery with and disengaging the same from the prime mover, without producing those sudden shocks which the use of ordinary clutch-boxes occasions, to the serious injury of both the article under operation and the machinery itself, have of late years been made the subjects of much enquiry. The principal ones in use are those invented by Mr. John George Bodmer, and introduced in various bleach-works in the neighbourhood of Manchester, where they are used in connection with the heavy mangles and callenders to great advantage. Mangles and callenders requiring from 30 to 40 horse power are, by this apparatus, connected with and disengaged from the engine, without stopping the same, and without any perceptible shock or noise being produced.

Mr. Bodmer effects his object by means of levers and knee-joints acting upon a series of segments lined with copper, which are brought into or out of contact with the internal or external surface of the rim of the driving wheel, thereby connecting the machine with or disengaging it from the driving shaft.

Now the author of this paper has thought that in many cases water, steam, or gas could be more easily and advantageously applied to force the segments against the rim; and he is about, with reference to the accompanying drawing, to explain a starting apparatus, in which water is employed as the medium of conveying the power to press the segments against the rim of the driving wheel.

The bevel pinion 1, Fig. 1, is supposed to be connected with the engine, or other prime mover, and gears into the bevel wheel 2, to which is cast a rim 3 which is turned internally. The wheel 2 turns loose upon the shaft 4, being lined with a brass bush 5; the shaft 4 however is provided with the four projections 6, through each of which a hole is bored, the centre lines of these holes lying in one horizontal plane, and meeting in one common central chamber 7. Into these holes the four rams 8, which are respectively cast of one piece with the blocks 9, are fitted; the blocks 9 being lined with copper, and turned so as to fit the internal surface of the rim 3. Supposing now that the machinery which is assumed to be connected with the shaft 4 required to be started, hydraulic pressure is applied to the rams 8, by pressing the ram 10 down

upon the column of water 10* within the shaft 4 and the chamber 7, by means of the flywheel 11 with its nut 12, and the screw 13, which forms one piece with the ram 10; the ram 10, nut 12, and screw 13 being guided and supported by the brass box 14, which is screwed into the upper end of the shaft 4. It is evident that on the ram 10 being thus pressed down, the rams 8 will gradually and simultaneously press the segments 9 against the internal surface of the rim 3, with a power proportionate to the force applied at the circumference of the flywheel 11, until the friction produced by such pressure shall be equal to the resistance of the machine to be set in motion. The machine will therefore gradually assume the velocity which, according to the speed of the driving shaft, it ought to have; at the same time that any extraordinary momentary resistance, such as might be supposed to occur occasionally in rolling mills, or other machinery of a similar nature, instead of causing the wheels to break, will have a tendency to make the rim 3 to slip on the segments 9 until the obstacle be removed or overcome.

In order however that too great a pressure may not be applied to the rams 8, the ram 10 and screw 13 are perforated with a small opening 14*, the extremity of which is closed by a valve 15, acted upon by a spiral spring 16, encased in the brass box 17, which is screwed to the top part of the screw 13; so that if at any time the pressure exerted upon the rams 8 should exceed that to which the spring 16 is regulated, the water would lift the valve 15, and escape through it into the box 17, and through an opening in the lid of the latter into the atmosphere, until the balance of the pressure was again established.

On the segments 9 requiring to be brought out of contact with the internal surface of the rim 3, it is only necessary to hold fast the flywheel 11, inasmuch as the screw 13 has a right or left thread cut upon it according as the shaft 4 turns either to the left or the right, and the rams are therefore immediately relieved, whereupon the machine stops.

It may be observed that the vacuum which is created in the column 10*, by the withdrawal of the ram 10, will in most cases be sufficient to cause the segments 9 to recede from the surface of the rim 3; otherwise that effect might be produced by the application of springs, or an elastic hoop.

The rams 8 and 10 are made good with press leathers in the ordinary way of hydraulic presses.

The paper was accompanied by a large drawing.

In answer to a question, Mr. JACKSON stated that he had had the apparatus at work for two or three months, and it had acted very well, and he thought that by it he had saved some horse power.

The PRESIDENT:—I think it is very ingenious, and calculated to be useful.

Mr. McCONNELL:—I observe that the regulation of the pressure upon the segments is provided for by an escape valve at the top. It is in fact a safety valve for preventing a greater pressure of water upon the rams. What I want to ascertain is, whether you can by any means so determine the pressure, that you can vary it according to the necessity of the case.

Mr. JACKSON:—You have only to screw the box down tighter.

Mr. McCONNELL:—Yes, but you may screw it down so tight as to snap the teeth.

Mr. FOTHERGILL:—There is a spring at the top.

Mr. McCONNELL:—That is what you may call a safety valve.

Mr. JACKSON:—Yes, and it will act the moment the pressure becomes too great.

Mr. McCONNELL:—But supposing it do not act (I am looking forward to that), in such a case you would be worse off than before, for trusting to a self-acting principle.

Mr. JACKSON:—By pressure upon the wheel the man can tell entirely by the feel.

Mr. McCONNELL:—I think it is a clever thing altogether.

Mr. FOTHERGILL:—Mr. Jackson has arranged it in a similar manner, as regards the pressure of the safety valves in locomotives, where the spiral spring is introduced. There is a certain spring, and a certain amount of resistance is necessary to allow the water to escape. If the person screws it beyond a given pressure, then this valve opens.

The PRESIDENT:—And lets the water out?

Mr. FOTHERGILL:—Yes; therefore it is self-acting from beginning to end. It is very ingenious, and highly valuable.

Mr. CRAMPTON:—In case any grease should get in, I think you would require a regulator.

Mr. FOTHERGILL:—A greater amount of power would then be required to be transmitted, in order to turn the rollers of the rolling mill;

but then there is a regulation to the pressure, for it discharges itself when it exceeds a certain force.

Mr. CRAMPTON :—May I ask what the objection is to the cones?

Mr. SLATE :—They get oval, and consequently jam themselves.

Mr. McCONNELL :—They begin to twist round, and get unequal in the surface, and only bear upon the point.

Mr. FOTHERGILL :—There is a great deal of lateral action where there is a cone.

Mr. BUCKLE :—There is considerable lateral action, and the pressure is directed endways; besides there is a danger of sticking.

Mr. SLATE :—I have seen a cone stick several times a day, and no ingenuity could avert it. The remedy was to put in a little oil, after which it would go on, but only for a day or two.

Mr. COWPER said he had had the conical clutches in use many years and if the angle be made just below the angle of friction, the pressure is moderate, and the cones do not stick.

Mr. SLATE:—You will always find it more or less difficult to define the angle of friction. The size of the cone I spoke of was fourteen inches at the top; I do not exactly recollect the taper, but it could easily be thrown out; it would break cast iron spindles of two or three inches diameter.

Mr. CRAMPTON :—I was yesterday in a large dredging boat, where the cone had been put in by Mr. Humphrys of London, one of the council of our Institution; the cone was four feet in diameter, but the principle had been altered, and it answered beautifully. Mr. Humphrys had made one before, but had not got the correct angle of friction, and he had put this one in, which he conceived to be right, and when I saw it it was going on well. Mr. Humphrys has a scheme for taking off the end pressure.

Mr. COWPER :—I can appreciate that. The first cone I made was not a correct angle, and it stuck fast; it was 1 in 13; I have since made them 1 in 6 and $6\frac{1}{2}$ and $6\frac{3}{4}$, and they work very well, but they must have some end pressure.

Mr. McCONNELL :—There is no way of taking off the end pressure without putting on a side pressure, in order to get the requisite grip to turn the shaft, and that I conceive is the point where great advantage will be gained by Mr. Jackson's mode; that he, without any pressure at all, by this expanding mandril (if we may so term it), suits the inner cylinder to the surface, or rather the inner cone to the surface

and the only point not clear to me was the safety valve; if it acts like the one described, and gives way just before the point of breakage, then we have every thing we desire. There is great objection to the ordinary cone, take what angle you will. If a piece of grit or too much oil get in, you are sure to have an accident.

Mr. JACKSON:—I have never seen a cone which would drive anything like the power that this is calculated for. The rollers were 3 to 3½ horse power, and I have never seen a cone which would turn 3 horse power.

Mr. CRAMPTON:—The one I refer to was about 35 horse power.

Mr. JACKSON:—Another objection to the cone is that the surface does not wear equal.

Mr. COWPER:—The cone I speak of did wear equal.

Mr. McCONNELL:—I think we are much indebted to Mr. Jackson for the introduction of this apparatus; it is very ingenious, and I think it possesses many advantages; I think that he is entitled to the thanks of the Institution. There can be no two opinions as to his plan being quite superior to the ordinary cone; and I beg to move "that the thanks of the meeting be given to Mr. Jackson for introducing the subject to our notice." The motion was seconded by Mr. COWPER and carried unanimously.

Mr. FOTHERGILL:—I think a communication of this kind ought to be made known to those of our members who have not had an opportunity of attending this meeting. I beg leave therefore to move "that Mr. Jackson's paper and accompanying drawing be printed and circulated amongst the members." The motion having been seconded was unanimously carried.

The PRESIDENT then called upon Mr. Buckle to read a paper by Mr. Edwin Chesshire, of Birmingham.

Mr. BUCKLE:—I beg to claim a little of your attention while I endeavour to describe what appears to me to be a very useful appendage to a railway train. I am of opinion that this apparatus, accompanied by the spiral break of our worthy President, will do all that can be done in averting the serious calamities attending the casualties on railways. The following is Mr. Chesshire's paper:—

ON CHESSHIRE'S SAFETY BUFFER.

The object of this invention is to lessen the injurious effects of collisions on railways, both to the passengers and the carriages of the train. To attain this, it is proposed to place in the rear of each train a strong van, which may be made applicable if thought desirable for the conveyance of luggage or goods. In the front of the train the tender is proposed to answer the same purpose as the van behind; the centre of gravity of each to be nearer the level of the rails than that of the other carriages.

Each carriage is to be supplied with a strong moveable rod of iron, either a tube or a solid, supported in the centre of the under framework by bearing sockets. The rod is intended to have simply an endway motion. Each safety buffer is to have a head at each end similar to the present side buffers, but the heads of the safety buffers are not intended to act against each other except in cases of collision. When the carriages are screwed up into their ordinary travelling state, there will still be a space between the safety buffers of some few inches, to permit the usual action of the side buffers, without acting at the same time upon the safety buffer.

In the van in the rear, and the tender in the front, the safety buffer will be fixed so that in either case it cannot have an endway motion further than being fixed against strong elliptical springs will permit of, if such springs are thought desirable.

It will be perceived that, in case of a collision, the moment the side buffers have been driven home to the extent of the interval between the safety buffers, the force of the collision will be instantly imparted to them, and be conveyed by that means from buffer to buffer to the further extremity of the train, either to the van in the rear or the tender in the front, according as the collision may happen to occur.

The safety buffer would, it is fully expected, have also the effect of preventing the carriages from riding one on the top of the other, which was the case in the Wolverton, the Nottingham, and other collisions, and the cause of so much destruction.

After the paper had been read, a series of experiments were made on a model railway erected at the back of the theatre. A train of carriages with the safety buffers was started from one end of the line, and another without them was set in motion from the opposite end. A collision took place

in the centre of the line, and the carriages to which the safety rods were fixed remained upon the rails, with the exception of the luggage van behind, while those without the rods were scattered about in all directions. The shock was received by the van, which, as Mr. Buckle stated, was intended to be loaded with heavy luggage.

The PRESIDENT:—I think one of the points must be to take the mass and the momentum, to see what the velocity is. It will surprise some of you who have not paid attention to these matters to know that, supposing a train starts with sixty waggons, the last waggon receives the greatest shock upon starting. The question is therefore whether, without these safety buffers, the last carriage does not get the shock. The momentum or force has to be stopped somewhere, and cannot be got rid of.

Mr. BUCKLE:—The shock is conducted to the last carriage, which Mr. Chesshire proposes to have filled with luggage. The public require that some experiments should be made with the view to avert the serious calamities occurring on railways, and this invention should at least be put to the test.

The PRESIDENT:—The momentum must be taken up by something, and what is that something to be? You may try any scheme, but you cannot prevent the momentum of the matter coming upon the engine in the event of a backward shock.

Mr. McCONNELL:—I am afraid there are practical objections to this invention, which would render it difficult to get the shock transmitted throughout the train. We know the difficulty there is to get the ordinary buffers all ranged horizontally on a line with each other. Now if this rigid bar is not transversely and horizontally in a line, I imagine it would not have the effect of transmitting the shock in the manner intended by Mr. Chesshire, and it would be liable to bend; so that, in order to have this scheme to act perfectly (supposing the principle to be right), it would be necessary that the carriages should be all of one height, and they must be in a straight line when the blow reaches them to be of any effect. On a curve the tendency would be to throw off the middle of the train, and not the end carriage at all, as forces go in a straight line. No doubt the last carriage receives the shock, and the centre carriages escape comparatively unscathed; but there are so many practical difficulties connected with carrying the plan into operation, that, looking at the number of cases in which it might be useful, and

those in which it would not act as it is intended, it appears to me very problematical whether it ought to be brought into use.

Mr. Fenton:—A curve is the place where the principle would not act, and I believe that that is the most likely part of a railway to meet with collisions.

Mr. Chesshire:—That collisions occur most frequently on curves I believe is an error. I have been in conversation with an eminent engineer, who stated that the very place where he would anticipate a collision was the very place where it did not occur. They rarely happened on curves, because there the driver was more particularly on the look out.

Mr. Joseph Wright:—An objection which I see to Mr. Chesshire's scheme is, that all the carriages must be constructed upon the same principle; for if any one has not that apparatus, it becomes inefficient, the connection having been broken.

The President:—Yes, there are now many thousands of carriages at work, and it would be a serious matter to alter them all.

Mr. Wright:—Besides, I do not see a proper mode of connecting the carriages. It is necessary that the ease of the carriages should be consulted, as well as the safety; and therefore that the carriages should be screwed up tight; and I think the means of connection is destroyed by the longitudinal rods. With them you cannot apply the screw in the same way as at present. But suppose the collision take place upon an incline, and the last carriage is thrown back, as proposed, where will it go to?

A Member:—To make another collision.

Mr. Wright:—Yes, most likely it will; I do not think the plan is sufficiently matured at present to be brought into practice; or rather, I may say, it is too late to bring it into practice, because there are so many thousands of carriages now in use, that the alterations would involve an expense which no company would incur; and in cases of lines running into each other, such as the London and North Western, where there are nine different lines intermixed, the plan would be impracticable.

The President:—I think there would be great difficulty in bringing the invention into use on old railways.

Mr. Buckle:—Have you ascertained the cost of fitting up the apparatus?

Mr. Chesshire:—It would be about £6 or £7 per carriage.

Mr. Wright:—Then there are between sixteen and seventeen thousand carriages in operation on the London and North Western, and if you multiply that by seven or eight you will find that the great cost raises an objection which it will be difficult to get over, particularly at the present time, when the companies have no money to spare.

Mr. McConnell:—I think public safety is the first consideration; and a little expense ought to be borne, provided it is to obtain that object; but the objection which Mr. Wright has stated would operate very strongly against the adoption of the plan before the meeting, unless there was some government enactment, binding every company to adopt it. We ought however to look at it as a question of principle. It is the duty of those who are entrusted with the practical working of railways, to point out, as far as experience guides them, the difficulties that would be met in carrying any scheme into operation; and it is very clear that in adopting this buffing apparatus it would be necessary to alter the mode of connecting the carriages, and that must not be done so that when you come to adopt it you may find, that although you have a problematical advantage one way, you have a decided disadvantage the other; and if the rods prove to be too light, and bend or swerve, I can easily imagine that the consequence would be the total destruction of every passenger in the carriage where the rod broke. I believe that every one would be smashed to atoms; because into that particular carriage would be landed the effect that was intended for the last carriage. Supposing also a collision to take place in the usual way, the present buffers would receive the shock in different proportions.

Mr. Wright:—The amount of force is expended before all the buffers are brought into action. There used to be a stationary buffer at Euston station, and on a recent occasion a train went too far, and ran into it. The check was received by the first carriage, and by the time the shock reached the last, its power had been so expended that the passengers in it knew nothing of the collision.

The President:—I was once on a train where two men were killed by a collision, and in the fourth and fifth carriages the shock was not felt in the least.

Mr. Chesshire:—I think the safety of the public positively demands that something of the kind I propose should be brought into practice.

I had an interview at the Board of Trade with Lord Clarendon and General Pasley, and submitted my model to them, of which they approved. I am quite satisfied that if this Institution were to recommend my improvement, every railway company in the kingdom would take it up. As to the objection of its interfering with the couplings now in use, I would say, why confine ourselves to these particular couplings? I am confident better ones might be introduced.

Mr. McConnell :—Mr. Chesshire should not lose sight of this, that if a train comes up, and it is proposed to transmit its force backwards through these buffers, it has nevertheless the momentum of all the other carriages coming up to it. It would transmit its force through the rod to the last carriage, which, naturally enough, would break its couplings and fly back; but still there is the whole momentum of the train at 30 miles an hour coming up against the engine, which you would stop so suddenly.

Mr. Peacock :—Supposing a train of carriages to run against a dead stop, or a stationary buffer, at the rate of six or eight miles an hour, the first carriage of course stops momentarily, the second carriage receives a less amount of shock, the third still less, and so on, till towards the end of the train it becomes insensible. That is the effect of our present system of buffers. The only difference between them and Mr. Chesshire's is this; that his method would communicate the shock to the first and last passengers at the same time, instead of distributing it gradually, so that we should lose the advantage afforded by the present system.

Mr. Cowper supported the view taken by Mr. Peacock. The invention, he said, amounted only to stiffening the under frame of the carriages.

Mr. Chesshire reminded the meeting that he did not contemplate interfering in the least with the side buffers. His plan would admit of the side buffers of all the other carriages acting, because the shock would be so instantaneous that the last carriage would be disconnected before the others came in contact.

Mr. Fothergill :—The buffers would not, I think, be of any use with these rods, because they would not come in contact before the force was expended throughout the whole of the train, and you ought to fix upon a good distance for the buffer to work in satisfactorily.

Mr. Ramsbottom :—With the present system, if the buffers are supposed to have a range of 12 inches, we do not get a dead shock; the first carriage will have to move through a space of two feet before its motion

is arrested; the next carriage will have four, the next six, and so on; and we can easily suppose the continued action of the whole of the buffers to be equivalent to putting on a break for two or three hundred yards. But if we look at the action of the safety rods, it is clear that the shock must be conducted simultaneously to the whole of the carriages at one time, and the whole velocity of the carriages resisted in the space of one foot; making the shock much more severe in proportion, if the ordinary buffers are not intended to go home till the rods come into play.

The PRESIDENT:—You do not stop a bit of the momentum, but only carry it to the end of the train.

Mr. CHESSHIRE:—It is transferred to the van, and there it is expended.

Mr. McCONNELL:—I think Mr. Chesshire had better let this matter now be ended here. We seem not to agree upon the subject, and I would recommend him to have a conversation upon the matter privately with the Council. They may perhaps be able to convince him that there are objections to his plan which he does not see at present.

Mr. CRAMPTON:—I have been endeavouring to make myself acquainted with the invention, and though I confess I do not feel very clear about it, yet the result of the experiment which we have witnessed occurs to me, and I really think there is something in it. I think it is worth our attention, and we ought to look at the thing in a scientific point of view, in order to learn whether it is right in principle; because if it is, the difficulties made by Mr. Wright ought not to stand in the way.

The PRESIDENT:—I want to get something to take up the momentum, and Mr. Chesshire has not managed to do that.

Mr. RAMSBOTTOM:—The shock cannot be received fairly if it is received either above or below. There will be a tendency to throw the train off the line. If the shock is distributed over a great space of matter gradually, it is divided, and the less severe will it be to the passengers.

Mr. CHESSHIRE thanked the meeting for the very patient attention they had paid to the subject; but he was still of opinion that, by the plan he proposed, the first and great shock must be conveyed through the safety buffers to the van behind the train, leaving the carriages uninjured.

Mr. FOTHERGILL then read the following statement of facts relative to Banks' Patent Steel Tyres, for steeling the tyres of railway wheels:—

BANKS' STEEL TYRES.

After an experience of five years, it is ascertained that the cost and durability of Staffordshire tyres steeled on this plan, as compared with the Low Moor tyres, is:—

Low Moor (Yorkshire); three feet Wheels.

Four tyres of 3 cwt. each = 12 cwt. at 22*s*.	£13	4	0
Putting on the tyres ready for work	8	0	0
Twice turning up, after wearing hollow	1	0	0
	£22	4	0

Suppose these tyres to run 50,000 miles on an average, it would give 50,000 miles at a cost of £22 4*s*.

Staffordshire; three feet Wheels.

Four tyres of 3 cwt. each = 12 cwt. at 12*s*.	£7	4	0
Putting on the tyres ready for work	8	0	0
Steel for steeling one set, 1½ cwt. at 42*s*.	3	3	0
Wages, turning grooves in wheels	0	10	0
Do. inserting the steel	0	10	0
Do. turning up after steeling	0	10	0
Do. drilling and rivetting	0	7	6
	£20	4	6

These tyres are proved to run 18,000 miles before steeling, and 100,000 after steeling; making a total of 118,000 miles at a cost of £20 4*s*. 6*d*.

The 50,000 deducted from 118,000 leaves 68,000 miles in favour of the Staffordshire tyres, besides a saving in cost of 39*s*. 6*d*. per set; the cost of the Low Moor tyres being 8*s*. 10½*d*. per 1000 miles, whereas that of the Staffordshire is only 3*s*. 5¼*d*. The tyres are not of course worn out alike on all railways; but on those lines where the iron tyres will run more than is here stated, the steel tyres will run more in proportion, and the plan is attended with no danger whatever.

This statement shows only the advantage of steeling the tyres once; but many have been steeled a second time, after having run the above mentioned distance. The cost of the second steeling is £5 per set, for which they will run 100,000 additional miles; making a total of 218,000 miles at a cost of £25 4*s*. 6*d*., or 2*s*. 4*d*. per 1000 miles.

The general objection made is that there will be much trouble in carrying out the plan; but such is not the case. When the wheels require turning up, they must be taken from under the carriage or wagon; and when so taken, the cutting of the grooves in the tyres for the steel will not cost more than 5*s*. 0*d*. per pair in wages. When the grooves are turned, one smith and three strikers will insert steel segments into ten pairs of three feet wheels, in one day of ten hours; after which, turning up the steeled wheels will take very little more time than turning up without steeling; which proves that the trouble will not be so great as is imagined, and nothing, when the durability and saving which is effected by the tyres being steeled on this plan is considered.

The statement was accompanied by a recommendatory letter from Mr. Jenkins, locomotive superintendent of the Lancashire and Yorkshire Railway, dated 28th January last. It stated that these patent steel segments had been inserted in the wheel tyres of the engine "Oldham," and that she had run 58,866 miles with them when the crank axle broke; the wheels were then taken off, and not again used until they were put to the engine "Queen," on 12th November, 1846. From that time to 31st December, 1847, they ran 29,482 miles, making a total of 88,348 miles; and should no accident occur, Mr. Jenkins is of opinion that they will run 40,000 or 50,000 miles more. He believes that there is a great saving of expense in using them.

The PRESIDENT said he supposed it was generally known that these tyres did wear well. Some of them were liable to a great loss, but on the whole he thought they made a good wheel.

Mr. McCONNELL thought they required to have a strong tyre in the first instance, in order to have sufficient body to prevent the widening of the grooves in which the steel is inserted, and that they also required to be put in very carefully.

Mr. PEACOCK said he had tried a great number of them, especially upon tenders: indeed he had some which worked five feet wheels, and they answered very well. The principal trials however had been on tenders, 3 feet 6 inch wheels, on the Manchester and Sheffield Railway, the gradients of which were very heavy, and he found that on an average they were obliged to change the tender wheels about once in four months.

The first which were tried with Banks' mode of steeling ran twelve months. This proved that they were a great saving, for tenders especially. They had had some which ran nearly 30,000 miles under an engine, and they worked very well.

Mr. McConnell believed there was economy in them, and where there was a great deal of breaking in the wheels, and skidding, the steel would stand much better. But he would really prefer a good tough iron tyre. One of the segments falling out might neutralize a great deal of the good effect.

A Member said he had seen an instance of a segment breaking off, and there was no bad effect.

Mr. Ramsbottom said an impression had gone abroad, that Banks' tyre pretended to make a bad wheel good; but the wheel must be good in itself. Some experiments were about to be made to test how far iron segments would be preferable to steel in this respect, as the same body of iron could be made closer in the grain and more durable. At some future time, if thought desirable, he would be prepared to lay before the Institution the result of those experiments.

The business having been brought to a conclusion, the President expressed himself well pleased with that evening's discussions, and he hoped that the next meeting would prove as interesting. Mr. McConnell's long expected paper "On the Balancing of Wheels" would be brought forward on the next occasion; and also one from himself "On the Fallacies of the Rotary Engine." That engine never had been and never could be used to advantage, and his paper would show the reason. It had been tried in Birmingham, and of course without success. Mechanics ought to know the reason of that. Very erroneous notions existed on the subject of the crank. The crank, he considered, was the most beautiful and efficient motion, and the idea that power was lost by it was a great mistake. It was in vain to attempt to evade the great law of mechanics,—a pound for a pound, a pound of weight for a pound of power; and no person who knew the law would think of opposing it. At the next meeting he would endeavour to explain the crank to the members, and to make them understand it, although many members of the Institution no doubt understood it well.

At the suggestion of several members, it was agreed to alter the time of meeting from five p.m. to four p.m.

Messrs. Cowper and Fothergill, as a Committee of the Council, opened the ballot returns, and declared the following gentlemen elected Members and Honorary Members :—

MEMBERS.

John Ashbury, Albion Carriage Works, Manchester.

Thomas Auster, Messrs. Auster and Smith, Easy Row, Birmingham.

William Bagnall, Messrs. Bagnall and Sons, Gold's Hill Iron Works, Westbromwich.

William Baker, Engineer of the Shropshire Union, Shrewsbury and Birmingham, and Birmingham Wolverhampton and Stour Valley Railways, 28 Waterloo Street, Birmingham.

Charles De Bergue, Engineer, 9 Arthur Street West, London Bridge, London.

J. O. Butler, Messrs. Butler and Co., Kirkstall Forge, Leeds.

James Carstairs, Engineer, Dewsbury.

Edward Corry, Messrs. Adams and Co., Fairfield Works, Bow, London.

J. C. Craven, Locomotive Superintendent of the London Brighton and South Coast Railway, Brighton.

Robert Crosland, Union Foundry, Bradford.

William W. Cutts, Rockingham Works, Sheffield.

Christopher H. Dawson, Low Moor Iron Works, Bradford.

Charles Denton, Engineer, Bromley New Town, Bow Common, London.

David Elder, Messrs. Robert Napier and Co., Engineers, Glasgow.

Douglas Evans, Engineer, Warsaw.

George Allen Everitt, Kingston Metal Works, Birmingham.

Benjamin Gibbons, Iron Manufacturer, Shut End House, near Dudley.

Nathan Gough, Engineer, Manchester.

James Gow, Locomotive Superintendent of the Leeds and Thirsk Railway, Leeds.

Thomas Grainger, Engineer-in-chief of the Leeds and Thirsk, and the Leeds Dewsbury and Manchester Railways, 119 George Street, Edinburgh.

James Gray, Steel Manufacturer, Sheffield.

Charles Green, Patent Brass Tube Works, Leek Street, Birmingham.

William Hartree, Messrs. John Penn and Co., Marine Engine Builders, Greenwich.

Robert Hawthorn, Messrs. Hawthorn, Locomotive Engine Works, Forth Banks, Newcastle-on-Tyne.

Robert Hughes, Superintending Engineer of the Steam Department, Admiralty, London.

Richard William Johnson, Bromsgrove Railway Carriage and Wagon Company, Bromsgrove.

William Johnston, Engineer of the Glasgow and South Western Railway, Glasgow.

Thomas William Kinder, Bromsgrove Railway Carriage and Wagon Company, Bromsgrove.

William L. Kinmond, Messrs. Kinmonds and Co., Wallace Foundry, Dundee.

Samuel John Knight, Messrs. Knight and Cumming, Waterside Iron Works, Maidstone, Kent.

Edward Lawson, Hope Foundry, Leeds.

Benjamin Lewis, Messrs. F. Lewis and Sons, Stanley Street Works, Salford.

Sir John Macneill, Engineer-in-chief of the Principal Irish Railways, 28 Rutland Square, London.

John Matthew, Messrs. John Penn and Co., Greenwich.

Edwin Marshall, Railway Carriage Builder, Birmingham.

Samuel North, Locomotive Department, London Brighton and South Coast Railway, Brighton.

John Penn, Messrs. John Penn and Co., Greenwich.

Robert B. Preston, Messrs. Fawcett and Preston, Engineers, Liverpool.

Edward Rishton, Engineer, Leeds.

James F. Roberts, Locomotive Superintendent of the Waterford and Kilkenny Railway, Waterford.

Henry Robertson, Engineer-in-chief of the Shrewsbury and Chester, and Shrewsbury and Hereford Railways, Chester.

John M. Rowan, Messrs. Rowan and Co., Engineers, Atlas Works, Glasgow.

Charles Sandford, Messrs. Sandford and Owen, Phœnix Forge, Rotherham.

William Prior Sharp, Messrs. Sharp Brothers, Atlas Works, Manchester.

Henry Sharp, Messrs. Sharp Brothers, Atlas Works, Manchester.

Archibald Sinclair, Messrs. Adams and Co., Fairfield Works, Bow, London.

Norman Henry Smith, Messrs. Auster and Smith, Easy Row, Birmingham.

James Stirling, C. E., Edinburgh.

Robert Thornton, Locomotive Superintendent of the North British Railway, Edinburgh.

HONORARY MEMBERS.

William Charles Alston, Elmdon Hall, near Birmingham.

William Eagle Bott, Secretary of the Leeds Dewsbury and Manchester Railway, Leeds.

Henry Cole, Keeper of the Public Records, Branch Record Office, Carlton Terrace, Westminster.

Samuel Crosby, Coleshill Street, Birmingham.

Henry Heane, Solicitor to the Shropshire Union Railways Company, Newport, Salop

John Lord, Agent for the Zealand Railway Company, Birmingham.

William Overend, Barrister, 3 Paper Buildings, Temple, London.

C. P. Roney, Secretary of the Eastern Counties Railway, London.

PROCEEDINGS.

June 13, 1848.

A Special General Meeting of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Tuesday, the 13th of June, 1848; J. E. McConnell, Esq., Vice-President, in the Chair.

The Minutes of the last meeting were read by the Secretary, Mr. Kintrea, and confirmed.

The Chairman stated that, in consequence of the unavoidable absence of the President, the paper "On the Fallacies of the Rotary Engine" would not be brought forward until the next meeting; it therefore fell to him to commence the proceedings, by reading his own Paper:—

ON THE BALANCING OF WHEELS.

The advantages derivable from balancing the wheels of locomotive engines and railway carriages and wagons are very important; and the object of this paper is to bring the subject more prominently before the members of the Institution of Mechanical Engineers, in order that the value of balancing railway wheels, and also all other machinery, may be properly understood.

There is a class of accidents which, from their frequent recurrence and the evil consequences resulting therefrom, require the careful attention of engineers connected with railway business: I mean those accidents where, from a rapid rate of travelling, the oscillation progressively increases in violence, and in a jumping or jerking motion, causing the engine or carriages to jump from the rails; and I hope to

demonstrate that the origin of these frightful cases, causing loss of life and immense damage to the property of the railway companies, is simply the absence of a proper equilibrium in the movement of the wheels and machinery of the engines and carriages; and although there may have been, in one or two instances, a fault in the rails or condition of the permanent way, even that was produced by the irregular working of the same machine on previous occasions.

Before proceeding to explain the results of many experiments and the rules which they afford, I wish to mention that the merit of instituting the first systematic enquiry into the effects of balancing wheels is due to Mr. George Heaton, of Shadwell Street Mills, Birmingham, who, since his attention was drawn to the subject in the year 1810, has laboured earnestly to effect a proper plan of balancing wheels in all kinds of machinery. Here it may not be out of place to read a description of the origin of his investigations, as detailed by Dr. Melson when delivering a lecture on Physical Mechanics, at the Birmingham Philosophical Institution, in the year 1842; possibly in the room in which we are now assembled:—

"It was in the year 1810, whilst Mr. Heaton was employed at Combe Abbey, by the late Earl of Craven, in a part of his lordship's establishment kept for the amusement of himself and his visitors in the practice of mechanical pursuits, as turning, sawing by circular saws, ornamenting by the aid of rose engines, &c., the covers of snuff boxes and other fancy articles, that, finding his hand power insufficient, his lordship determined to have a small steam engine erected, of sufficient power to drive the lathe, &c., at the requisite speed. The engine having been put up, his lordship and many of his visitors were surprised to find, that when one of the lathes was urged to a speed of about 600 revolutions in the minute it began to shake, and shook to such an extent as the speed was augmented as to raise the whole lathe and frame from the floor upon which it was placed. Mr. Heaton was of course consulted as to the cause of this agitation, and he attributed it unhesitatingly to the fact that the revolving parts of the machine, the pulleys, were not equal in weight on both sides of the centre. The lathe was of beautiful workmanship, made by one of the best makers in London, and the pulley suspected of the fault was made of rosewood, on which was fixed a dividing-plate. Now it was

probable that the texture of the wood being closer on one side than on the other when *dry* was the cause of this inequality in the weight. Mr. Heaton had immediate instructions to remedy this defect if possible, and he accomplished it in the following manner:—he bored a hole on the light side of the pulley 3½ inches from the centre, and introduced into it 9 ounces of lead, which was the quantity required to make the pulley perfectly in balance. The lathe was now again set to work, and at a speed of 600 revolutions per minute or any other speed requisite for its work it was perfectly free from shaking. This rocking motion was now illustrated on a large model, whose axis was of the breadth of the ordinary railway gauge, and its two revolving rods of the length of the diameter of the wheels of a locomotive engine. Being unequally balanced, and made to revolve by a weight of 6 lbs., it exemplified the rocking motion of the lathe. The same motion, Dr. Melson observed, may also be noticed in some of the guide pulleys that are heavy-sided on the railways, where a rope is used to draw the train along, particularly when the train runs fast. Here several corrections of machinery, both of lighter and more ponderous construction, were severally detailed, in which Mr. Heaton had succeeded, by attention to this principle, in producing an equable motion, where before the most violent and unaccountable agitation had prevailed. One striking instance occurred in the latter part of last year: an application was made to the firm of Heaton Brothers, Shadwell Street, for instructions to remedy the evil attendant upon the working of a fan used for the purpose of creating a blast for melting iron; this fan had been set to work, but the steam engine by which it was driven was found incapable of getting it up to the required speed, which was about 1000 revolutions per minute, and when it approached that speed it shook the whole of the buildings, and shook itself loose from its bearings. To obviate this position of affairs, the proprietors removed it into another position, and propped it with strong timbers, which strong timbers had their bearing under a heavy wall. When again set to work it shook the whole place as before, and made so much noise that the proprietors were threatened with a prosecution for nuisance. At this critical juncture of affairs, Messrs. Heaton, having been consulted, immediately took the fan to pieces and found it 2 lbs. 8oz. out of balance. The evil was rectified, and the fan restored to

its former position, short of the whole of its props, &c. The engine was now set to work, and was found capable of driving the fan the requisite number of times, the nuisance was removed, and the fan had never since displayed any disposition to move from the place where it was set. Here an important observation was made, to the effect that the outside of the wings of this fan, which was 3 feet in diameter, when running at 1000 turns per minute, does not travel quite twice as fast as the rim of the wheels of a railway train when the train is running at the speed of 30 miles an hour. The motion of the fan was now imitated on the large model, in which experiment the weights on the outside of the steel rods were not propelled at the rate of 15 miles an hour, although the effect was so violent; whilst at the same time the weights travelled at a uniform speed in each part of their revolution. This was not the case with the wheels of a railway train; for if a train were travelling at the rate of 30 miles per hour, the top part of the wheels would of course have a much greater motion than the centre. If then such an effect were produced by the model, when only 12 ounces out of balance, and only moving that 12 ounces at the rate of 15 miles per hour, what effects were we not prepared to expect from a railway wheel thrown forward at four times the speed, and where, as in many instances was the case, the wheels were each four times that much out of balance."

I could also, if necessary, instance several recent accidents on railways, resulting I believe from the same cause, and also from a want of balance of another description, to which I mean to direct the notice of the members of this Institution at a future meeting.

The more clearly to account for the great effects produced by balancing wheels, I have carefully noted the experiments made, in order to found some general principle by which they are to be regulated; and I find that the laws of central forces will afford the proper data. By the laws of central forces, when a body is made to revolve in a circle round some fixed point, it will have a continuous tendency to fly off in a straight line, at a tangent to the circle, which tendency is called the centrifugal force; and the opposing power by which the body is retained in the circular path is called the centripetal force, and both forces when taken together are termed central forces. Now it must be self-evident that the centrifugal forces of two bodies of

unequal weight, moving with the same velocity of revolution, at the same distance from the centre, are to one another as the respective quantities of the two bodies. Further, the centrifugal forces of two equal bodies which perform their revolution round the centre in the same time, but at different distances from it, are to one another as the respective distances from the centre. The centrifugal forces of two bodies which perform their revolution in the same time, and whose quantities of matter are inversely as their distances from the centre, are equal to each other. The centrifugal forces of two unequal bodies moving at equal distances from the centre, with different velocities, are to one another in the compound ratio of their quantities of matter and the squares of their velocities. The centrifugal forces of two equal bodies moving at equal distances from the centre, but with different velocities, are to one another as the squares of their velocities. The centrifugal forces of two equal bodies moving with equal velocities at different distances from the centre are as their distances from the centre. The centrifugal forces of two unequal bodies moving with equal velocities at different distances from the centre are to one another as their quantities of matter multiplied by their respective distances from the centre. The centrifugal forces of two unequal bodies moving with unequal velocities at different distances from the centre are in the compound ratio of their quantities of matter, the squares of their velocities, and their distances from the centre.

Without entering on the wide subject of central forces, which would require more space and mathematical reasoning than this paper can embrace, I shall now illustrate by a few examples on the models before the meeting the effects of wheels unbalanced and in balance.

In order to arrive at a correct principle of balancing wheels, it is only necessary to find out by a delicate apparatus,—such as by having the wheel suspended by the centres of a lathe, or other centres, so that there may be as little friction as possible in revolution, and then by tying a weight at the periphery of the wheel to overcome the inertia,—the difference required at one point more than another, necessary to place the wheel in perfect balance. This test is only necessary at four points; having first discovered the heaviest side, the opposite or lightest, and then the other two at right angles to these, proceed to place balance weights as required.

With engine wheels on a crank axle, it is necessary to attach all the rods and other appendages which increase the weight of the wheel in revolving, and consequently great care is necessary to place these parts in their natural position, as when at work.

It is a fact worthy of notice, that two wheels cannot be balanced on the axle at the same time. One wheel requires to be put on and fairly balanced by itself; and when properly adjusted, the other is added; and precisely the same process must be again performed.

In connexion with this subject, I have observed a singular effect produced by a want of balance, which may be very interesting. In the year 1846 a number of powerful merchandise engines were delivered by various makers to the London and North Western Railway Company; and so far as the plan and construction of the engines were concerned, the company was satisfied; but in a short time a flat place was found on the tyre of the wheels, exactly opposite to the crank. Many reasons were assigned for this, but none were correct; and the matter was submitted as a fatal objection to the engines. I was consulted on the subject, and at once gave it as my opinion that the sole cause was a want of balance. An engine was put in balance; and the cause being removed, the engines were again restored to favour.

The saving in power by the wheels being put in balance is very considerable; and I know from experience, that were this subject taken up with a desire to put all wheels in balance as perfect as possible, 10 per cent. of traction force would be saved.

I have now to introduce to the meeting a small model showing the advantages of another kind of balance, which in its results will I believe do as much for the prevention of accidents as even the balancing of wheels: I mean the balance to the momentum of piston and rod. As it will however form the subject of a future paper, I shall merely submit the model to the members: and I trust they will give the matter their earnest consideration.

The following is a Table of experiments with the small model No. 2, composed of an upright spindle having a piece of brass wire 12 inches long, weighing 4 ounces, put through the top part of it, in such a manner as to allow of its being moved, and set longer at one end and shorter at the other, &c. The weight to give motion fell through a distance of 2 feet 4 inches in each experiment.

Table of Experiments.

No. of Experiment.	Particulars of Experiment.	Weight to give Motion.	Time in Motion.	No of Revolutions.
		Lbs.	Seconds.	No.
1	The wire set in the spindle with the ends at equal lengths from the centre.	1½ 3 6	45 46 46	165 206 241
2	The wire set all out on one side of the spindle, and consequently out of balance.	1½ 3 6	32 33 30	56 56 57
3	The wire set 4 inches long at one end and 8 inches long at the other.	1½ 3 6	32 30 29	72 78 85
4	The wire with a 6 oz. weight upon one end, and set in the spindle in such a manner as to make each end of an equal weight.	1½ 3 6	56 56 59	143 173 206
5	The 6 oz. weight removed, the wire remaining in the same position as in the last experiment, No. 4.	1½ 3 6	36 33 29	67 70 69

The model No. 4 was made to more nearly resemble the railway carriage wheels and axle. It consists of a round axle fixed to run in two brass chairs, resting upon a small wood frame, with an eight-day clock spring and barrel upon the frame, to give motion to the axle, and by that means to keep its power within itself. There are two flanged wheels, one on each side of the axle, 6½ inches in diameter, bearing about the same proportion as a railway carriage wheel; by placing some loose pieces of iron inside of the wheels so as to make them represent wheels that are ⅛ inch thicker on one side of the periphery than the other, and the thick sides on the opposite side of the centre (a position which it is the practice of wheel makers to place them in, and which, according to the models, is the very worst), if the string from the spring barrel is wrapped round the axle and let go, the model will begin to jump about the table; or if held in a person's hand, it will soon get the whole into a shake, so as to beat time with it in a similar manner to many of the railway carriages.

In the course of the reading of the paper, Mr. McConnell exhibited numerous experiments explanatory of the subject. The first showed the wheels of a model machine in balance, to which motion was communicated by a spring; and the regularity of the motion of the wheels was strikingly evinced. Afterwards a small piece of iron was inserted between the arms of each wheel at opposite points, which entirely destroyed the balance, and gave rise to considerable jerking or unsteadiness. Similar experiments were made to show the advantage of also balancing the piston rod, which more than anything else, Mr. McConnell believed, would obviate the unpleasant and sometimes dangerous jolting of railway trains.

With respect to the mode of balancing wheels, Mr. McConnell stated that two wheels could not properly be balanced together: first one is balanced, and then the other on the opposite side. When this subject was first brought under the notice of Mr. Robert Stephenson, it was not considered to have any value, and it had many opponents; but more recently Mr. Stephenson's attention and that of other eminent engineers had been called to it, and their opinion was now favourable. These parties however adopted another method, which he (Mr. McConnell) did not consider to be the correct one; namely, when a locomotive is to be connected, and the driving wheels and working parts to be attached, it is lifted upon centres and the wheels set slowly in motion, balance weights being added until they move at a particular speed without rocking, and become perfectly settled on their centres. That plan might answer tolerably well, but he did not consider it to be the really true method of balancing wheels. On a future occasion he would probably bring before the Institution the subject of balancing the piston and rod and connecting rod, to which he attached very great importance. He believed the want of this balance to have caused many such accidents as engines leaving the rails, even when the wheels were in balance; for when an engine attains a high velocity, say when the piston rod travels at the rate of 1000 feet per minute, the momentum of the piston becomes so great, that the engine must jump and oscillate, causing the front wheels frequently to clear the road. This effect he had succeeded in completely neutralising, in experimenting at Wolverton with an engine perfectly balanced. It was six years since Mr. Heaton introduced the subject to him

(Mr. McConnell), and he then adopted it on the Birmingham and Gloucester Railway. He believed that to have been amongst the first instances of its having been brought into practice.

Mr. Middleton said he knew that considerable prejudice had at one time existed against the system of balancing, so ably brought forward by Mr. McConnell. He had been associated with the author of the system, Mr. George Heaton, in having it tried on the London and Birmingham and other Railways, but they met with great discouragement. He was however still convinced that it was one of the best means of securing the utmost safety in railway travelling. It was first introduced in 1839, on the London and Birmingham line; and he had also then been in communication with Messrs. Sharp Roberts and Co., of Manchester, on the subject; but it was, as Mr. McConnell had stated, first adopted in practice on the Birmingham and Gloucester line.

Mr. McConnell observed that Messrs. Sharp Roberts and Co. did not take the true plan. Instead of balancing each wheel and each crank by itself, they put a balance weight opposite to the two cranks; and that system they carried on for a considerable time.

Mr. Cowper said that Messrs. Braithwaite and Milner had balanced wheels on the Eastern Counties lines eleven years ago; and after coming to Birmingham he had heard of Mr. Heaton's plan, which he found to be precisely the same as that on the Eastern Counties. This however was a decided improvement on any he had seen before.

On the motion of Mr. Henry Smith, seconded by Mr. Samuel Thornton, the unanimous thanks of the meeting were voted to Mr. McConnell for his valuable paper, and for the very complete experiments he had exhibited.

The Secretary then read the following Paper, by Mr. James Samuel, of London :—

ON AN EXPRESS LOCOMOTIVE ENGINE.

The small locomotive lately introduced on the Eastern Counties Railway having attracted considerable attention, has induced me to present to your notice a short description of it; and at the same time to offer a few observations on the applicability of the principle to the conveyance of passengers on branch lines of railway.

This "carriage engine" was constructed, under my superintendence, for the purpose of conveying the inspectors and myself on the Eastern Counties Railway, and thereby avoiding the great expense of special engines.

The total length of the carriage is 12 feet 6 inches, including machinery, water tank, and seats for 7 passengers; all on one frame, which is hung below the axles, and is carried on four wheels 3 feet 4 inches in diameter. The floor is within 9 inches of the level of the rails. It is propelled by two cylinders, 3½ inches in diameter, with a 6 inch stroke, placed on each side of the boiler, and acting on a crank axle. The boiler is cylindrical, placed vertically; and is 1 foot 7 inches in diameter, by 4 feet 3 inches in height. It contains a firebox, 16 inches in diameter, by 14 inches in height; with 35 tubes, 3 feet 3 inches long, by 1½ inches in diameter; giving 5½ feet of heating surface on the firebox, and 38 feet on the tubes. The engine is fitted complete with link motion, feed pumps, &c. The water tank is placed under the seats, and will contain 40 gallons.

This carriage is capable of conveying 7 persons, at a rate of 30 miles an hour; it has at times attained a speed of 44 miles. The consumption of coke is only 2½ lbs. per mile; and the weight of the whole machine does not exceed 25½ cwt., including coke and water.

The result of observations which I have for a considerable time been making on the Branch *Passenger* Traffic of Railways has been to convince me that, on the whole, it is not remunerative; and in some cases it is even worked at a loss. I have therefore been led to consider, whether the expenses might not be reduced by the introduction of a system of steam carriages more suitable to the amount of traffic to be conveyed.

It is evident that the more we can reduce the dead weight of the trains and engines, in proportion to the number of the passengers, the less will be the expense of repairs, both of the carrying stock and engines, and of the way and works of the line.

The average weight of a train on the branch lines of the leading railways is 56 tons, the number of passengers conveyed by each train not exceeding 35 to 40 on many of the branch railways in England. Supposing each passenger with luggage to weigh 1½ cwt., the total weight of the passengers conveyed is about 3 tons; or in other words, for every ton of paying load now carried by the system of locomotion, we have 18 to 20 tons of dead weight.

It is therefore in a commercial point of view of the greatest importance, not only to railway companies but also to the public generally, that some less expensive and at the same time equally safe means of transit be adopted.

Accordingly it is proposed to substitute for locomotives, on branch railways, steam carriages similar in construction to the accompanying drawings.

These drawings represent a patent steam carriage now in course of construction, under my direction, by Mr. W. B. Adams, the patentee; intended for the Eastern Counties railway company.

The following are a few of the principal dimensions:—diameter of cylinders, 7 inches; length of stroke, 12 inches; diameter of driving wheels, 5 feet; distance between centres, 20 feet; width of framing, 8 feet 6 inches. The boiler is of the ordinary locomotive construction, 5 feet long by 2 feet 6 inches in diameter; the firebox is 2 feet 10¼ inches by 2 feet 6 inches. There are to be 115 tubes 1½ inches in diameter and 5 feet 3 inches in length; giving 210 feet of heating surface on the tubes. The area of the firebox is 25 square feet; giving a total of 235 feet of heating surface on the boiler.

The consumption of coke I have estimated at 7 lbs. per mile at a velocity of 40 miles per hour. The total weight of the steam carriage, with coke and water, will not exceed 10 tons; and it will be capable of conveying about 42 passengers, at a speed of 40 miles per hour. The water will be carried below the floor of the carriage, in wrought iron tubes 12 inches in diameter and 12 feet long.

One great object attained in this machine is the reduction of the centre of gravity; from which there will be a consequent absence of lateral oscillation. It is intended for the Enfield and Edmonton branch of the Eastern Counties railway, and is expected to be at work in about 3 months from this date. When its practical utility and economy has been proved, I shall be glad to submit the results to the Institution; as I feel convinced that the subject is one deserving the attention of the members, and of all parties interested in the profitable working of railways.

I may add that were the system of light steam carriages adopted, branch railways might be constructed at a very small cost indeed, compared with the present outlay; an outlay which is unavoidable with the system of heavy engines; and the advantages of railway accommodation might be extended to districts which can never hope to enjoy them so long as the present system, which requires so great an outlay of capital, is continued.

Mr. Samuel begged to state that one of the chief recommendations of his engine was the very great saving it would effect in the wear and tear of rails, arising from the difference in weight between it and the present class of engines. From experience he estimated the wear and tear of rails at £80 per mile per annum; besides the wear in the tyres of the driving wheels, which all know to be large. In constructing branch lines, and also where the traffic was light, he proposed to lay light rails and to use only these little engines; and by these means, the first cost of such lines, as well as the current expense, would be very materially lessened.

In answer to questions by Mr. Cowper, Mr. Samuel said that there would be no difficulty in providing for the conveyance of goods or passenger trains more than usually heavy; and in answer to the Chairman he said that it would be desirable to lay the light rails he had spoken of on longitudinal timbers, so that heavy engines might, as occasion required, run over them with safety.

A Member enquired what amount of steam pressure the engine usually worked with.

Mr. Samuel replied that the usual amount was 120 lbs.; but it was not his intention to work with more than 80 lbs. in future.

The Chairman and Mr. Cowper concurred in thinking that for branch lines, where the traffic is not usually heavy, Mr. Samuel's engines might be used with considerable advantage and economy, and that by some such means these lines, generally so unproductive, might be made remunerative to the proprietors. The Chairman however thought an objection might be taken that the passengers would be subject to a delay at the junction with main lines.

Mr. Samuel replied that the delay would be amply compensated for by the increased speed he expected to obtain. He might add that he had made a calculation that the cost of conveyance of passengers by his arrangement would not exceed one fifth of a penny per mile. All would admit that the unprofitable working of most branch lines demanded that some means of economising the expenses should be introduced.

The Chairman did not think it advisable to lay down lighter rails than those now in use. In conclusion he begged to intimate that the engine in question was at the London and North Western Birmingham station, in steam, that the members might personally witness her working.

Mr. Buckle then proposed that the best thanks of the Institution be given to Mr. Samuel; the motion was seconded by Mr. Cowper, and passed unanimously.

Mr. Thomas Craddock, of Birmingham, having expressed a desire to lay before the Institution a supplementary paper to the one read by him at the last meeting, read the following Paper :—

ON A BOILER AND CONDENSER SUITABLE FOR EXTENDING THE CORNISH ECONOMY AND FOR PREVENTING BOILER EXPLOSIONS.

At the last meeting of the Institution several questions were put to me, some of which I was not at the moment prepared to answer. The question put by Mr. McConnell relative to the economy of my boiler in the generation of steam, when compared with the common boiler, I am not even yet prepared to answer; as I have not been able to find time to make such experiments with the two boilers as would enable me to make a conclusive reply. Before referring to other questions raised at that meeting, I will offer a few observations on the advantages of two cylinders when used for expanding steam from a very high to a very low pressure, as proposed by me. Mr. Crampton alluded to the loss shown by the curve of the indicator figure, and I am quite as sensible of this loss as Mr. Crampton or any one else can be; as long ago I publicly assigned that as the reason which had induced me to design and construct engines on the principles of the one now before this meeting, which on investigation will, I think, be found calculated to effect the object desired. But I wish to remind the meeting, that the indicator will not detect the loss alluded to as that arising from the steam being condensed by the comparatively cold metal of the cylinder; the water resulting from such condensed steam being in contact with the heated metal, and having free communication with the condenser, re-absorbs the heat, thus rendering that heat and water inert when we require it active, and active when we require it condensed. I think however that the validity of Mr. Crampton's assertion is open to question. He asserts that the flywheel will meet the objections without the two-cylinder engine. If the irregularities and other difficulties attending the one-cylinder system are not considerable, the flywheel will meet the difficulty; but the matter is very different when, as in my case, we avail ourselves of the expansive principle to the fullest extent; and to render that safe and practicable was the primary motive which led to these arrangements. To illustrate the matter, let us suppose it desirable to use steam at the commencement of the stroke at 200 lbs. per square inch; that steam being

reduced by expansion before it quits the cylinder to 3 lbs. per square inch, which would require the steam to be cut off at about $\frac{1}{64}$th of the stroke, to do which in one cylinder it must be of large capacity; hence we have 200 lbs. per square inch acting upon an extensive piston area at the commencement of the stroke, and at its termination only 3 lbs. It must be very obvious that this would produce immense strain upon all the working parts of the engine; to meet which they would require to be inconveniently heavy and strong; besides, what weight of fly-wheel would be required to equalise such a motion? Yet, with an engine on similar principles to the one before the meeting, all the difficulties are met by a reduction of weight and bulk of engine. The strain also upon the various working parts is kept quite as low as in the low pressure engine. I think if gentlemen will bear in mind these reasons, and others which will readily suggest themselves, they will agree with me that there are strong and valid grounds for concluding that the double cylinder engine does possess advantages for carrying out the expansive principle as I propose it; advantages which are supported by the soundest theory, and are confirmed by practice.

In replying to other questions, I shall endeavour to be brief. In large boilers, such as those exhibited in the drawings before the meeting, for marine and locomotive purposes, the extent of surface on which the heat generated in the furnace acts is 30 square feet for every 62 lbs. of steam required to be generated per hour; three fourths of such surface being exposed to the radiant heat and one fourth to the communicative heat. The extent of surface required in the condenser to condense 62 lbs. of steam per hour is 70 square feet when air is the medium of condensation. With water as the medium of condensation, 16 square feet of surface is sufficient for the condensation of 62 lbs. of steam per hour. With air as the medium of condensation, 62 lbs. of steam, generated under a pressure of 100 lbs., will with such engines produce at least 3 horse power. And with water as the medium of condensation, 4 horse power is easily obtainable from 62 lbs. of steam per hour. From this it follows, that the surface necessary in the condenser per horse power is one third of 70 square feet, or $23\frac{1}{3}$ feet; whereas with water as the medium of condensation, the surface required in the condenser will be one fourth of 16, or 4 square feet per horse power.

In reference to weight of boiler, condenser, and engine, I am prepared to state that the boiler, with casing, grate, steam chest, and all complete, does not exceed 1 cwt. per horse power. The condenser, when air is the medium of condensation, does not exceed $\frac{3}{4}$ cwt. per horse power; and with water as the medium of condensation, the condenser would not exceed 40 lbs. per horse power. The coal required, with air as the medium of condensation, is 3 lbs. per horse power per hour; and with water as the medium of condensation, it would be even less than 3 lbs. Again: we find the weight of boiler, condenser, and engine, even with air as the medium of condensation, not to exceed $2\frac{3}{4}$ cwt. per horse power. If we contrast this weight with that of the "Banshee" engines, lately tried in a government vessel, which is a fair weight of the present make of engines, we find the "Banshee" engine and boilers with water weigh 280 tons for 350 horse power. The weight of an engine, boiler, and condenser, on the principle of the one before the meeting, equal to 350 horse power, would not exceed 60 tons; which is not one fourth of those of the "Banshee": whilst I know that the consumption of fuel would be reduced nearer two thirds than one half of that necessary in the instance given.

Much was said at the last meeting about a comparison in actual work. Since then I have been informed by Mr. Humphries of Pershore, that with one of these engines, made for him by me, and which is far from being so perfect as experience would now enable me to make it, he thrashed 50 bags of "gardy" cut wheat with 3 cwt. of coals; whilst a neighbour of his with another engine thrashed 30 bags of wheat with 30 cwt. of the same quality of coal.

Mr. Craddock added that these boilers would, if necessary, generate steam at 200 lbs. pressure; and yet no such accident as that which had recently occurred at Dudley could take place. In answer to a member, he stated that he had been in communication with the Admiralty, who said they could not adopt his suggestion. He did not know what their opinion was, but his were not suggestions, they were facts; and he had an engine of nearly 100 horse power constructed on this principle.

Mr. Henry Smith wished to know the comparative power of working the refrigerator and the common pump.

Mr. Craddock replied that a condenser equal to 40 horse power would not take one horse power to drive it. It had been objected that the joints of the refrigerator were not tight; but he would engage to construct them perfectly so.

Mr. McConnell enquired how the water in the boiler was kept at a regular height.

Mr. Craddock replied that there were taps for the purpose.

Mr. McConnell said he had previously asked the question of the relative economy of this engine and the one somewhat similar to it in power at the London Works, and he did expect that either Mr. Craddock or Mr. Cowper would ere this have given the Institution some data to found an opinion upon.

Mr. Craddock said he had stated the relative economy to be 50 per cent., and it rested with Mr. Henderson and not with him to explain why the trial had not been made. He (Mr. Craddock) had always been anxious for it.

Mr. McConnell could not doubt the statement of Mr. Craddock, and he was anxious to give the engine every proper advantage; but when that gentleman talked of saving 50 per cent., it became an important matter to have some data by which to arrive at an opinion; and he thought the Institution should not be committed to anything which had not been accurately and sufficiently tested by experiment.

Mr. Cowper said 50 per cent. might seem rather large; but they knew that the Cornish engine effected a saving of nearly 60 per cent. over the old engines.

Mr. McConnell said his only wish was to prevent the Institution committing itself to an opinion, without having the merits of the engine fairly tested; but he would be quite willing to admit its superiority, whenever he had the proper data upon which to decide. The question of the relative advantages of the double and single cylinders was not yet settled, and one of the members had been requested at the last meeting to prepare a paper on the subject. He thought therefore that experiments should be made, in order to determine the relative economy of the two engines. It had been suggested to him, as the Chairman of the meeting, that a committee of members might be appointed

to make the necessary experiments with Mr. Craddock. If that would be satisfactory to Mr. Craddock, he believed that it would be satisfactory to the members of the Institution.

To this arrangement Mr. Craddock willingly assented; and the Chairman announced that the Council would name the Committee whenever Mr. Craddock intimated that he was prepared to carry out the experiments.

The Secretary then read the following Paper, by Mr. William Smith, of Dudley :—

ON THE RECENT BOILER EXPLOSION AT DUDLEY.

Having collected numerous particulars connected with the lamentable explosion of a steam boiler at the works of Mr. Jeffries, Hart's Hill, near Dudley, which occurred on the morning of Friday the 2nd inst., I have great pleasure in laying them before the Institution; and for the better elucidation of my statements, I have prepared a drawing of the section of the boiler, and of a puddling furnace which was one of four, the heat from which acted upon the boiler.

The boiler here alluded to is in this district termed "an egg-shaped furnace boiler," from being heated by puddling furnaces. The sectional sketch which I now produce will show the form, and also the distance and position in which it stood to the furnaces, one of which acted upon each quarter of it, at right angles; the flame from the neck of the furnaces coming first in contact with the lower part of the outside shell, and then ascending to the cross flues, passed through them, and descended through the vertical flue to the chimney.

I shall now state the dimensions of the principal parts; together with the calculations of heating surface, steam space, &c.

The boiler being, as before stated, egg-shaped, or rather a plain cylindrical one with hemispherical ends, there were four cross flues, and one main flue in the centre was placed in a vertical position, as shown

in the drawing. Its extreme height was 19 feet, and 9 feet 3 inches in diameter; the diameter of the four cross flues was 1 foot 10 inches, connecting the shell to the top part of the main flue, which was 5 feet in diameter at top, and 3 feet 9 inches at the bottom; the height from the bottom of the boiler being 14 feet.

The heating surface would therefore be :—

Outside shell	160	square feet.
Four cross flues	50	,,
Main flue	196	,,
Total ...	406	square feet.

Allowing 12 inches of water above the main flue would give 668 cubic feet contained in the boiler: the remaining space for steam would be only 169 cubic feet. In order to form an opinion as to the quantity of water evaporated per hour, the quantity of coal consumed in the furnaces must first be ascertained. It was as follows:—each furnace puddled between 22 and 23 cwt. of iron in 12 hours, and consumed between 28 and 30 cwt. of coal in six charges; and the operation is performed by first raising the furnaces to a white heat, until the charge of iron is melted, which takes about half an hour; after which the damper is shut nearly close until the puddling process is finished, which takes about 40 minutes; and the blooms are drawn out and the furnace reheated for another charge. We have then 29 cwt. of coal consumed by each furnace in 12 hours, and $\frac{29 \times 112 \times 4}{12} = 1083$ lbs. per hour; and supposing, under the circumstances, that 20 lbs. of coal would evaporate 1 cubic foot of water, we have 54 cubic feet per hour, which I think is nearly correct. The result then for comparison is :—

Heating surface	406	square feet.
Steam space	169	cubic feet.
Water space	668	cubic feet.
Water evaporated per hour	54	cubic feet.
Coals consumed per hour	1083	lbs.
Coals consumed for one cubic foot of water evaporated	20	lbs.
Diameter of steam pipe to engine	$5\frac{1}{2}$	inches.
Diameter of safety valve (one)	4	inches.
Diameter of feed pipe	$2\frac{1}{2}$	inches.
Thickness of all the plates of boiler	$\frac{7}{16}$	inch.
Pressure per square inch on the safety valve (supposed)	45	lbs.

The above facts show that the steam space in this boiler was much too small for the heating surface and for the other proportions of the boiler; and having examined the boiler on the 28th of April, I was aware of that fact, and advised Mr. Jeffries to make an addition to the steam space, as shown in my drawing by red lines. This boiler worked in connexion with another cylindrical boiler about 25 feet long and 5 feet 6 inches in diameter; of the ordinary construction, and heated in the ordinary way. Both together supplied steam for a cylinder 20½ inches in diameter and 6 feet 6 inches stroke, making 20 to 22 strokes per minute. About four o'clock on the morning of the accident this latter boiler was shut off, from being found to be leaking, and the boiler which exploded was left to work the engine by itself. This it did for about 2¼ hours, and then exploded. It appeared in evidence that the engine was doing very little work at the time of explosion, as it was driving only the gearing and a roll turning lathe at which the proprietor himself was working; but all the four puddling furnaces were in full work, and a great quantity of steam must have been blowing off by the safety valve, and the engine acting on the very small steam space had, in all probability, caused the boiler to prime, and suddenly thrown out a large portion of the water. I examined the pieces of the boiler about four hours after the explosion. The boiler was torn up in all directions; and I am convinced, from the appearance of the plates, that it had been short of water, and that the top part of the main flue, and the cross flues, had been red hot. I am also of opinion that the main flue had either collapsed in the first instance, or otherwise the crown of it had been forced downwards, and the steam or water descending into the main flue to the chimney had blown it up, as also the stack which stood at about six yards from the boiler. Other particulars will be seen in the evidence given at the inquest; but I am sorry to say that the real cause of the accident seems still to be a mystery; it not being possible to ascertain the exact amount of weight upon the safety valve at the time, from the great difference of statement made by the two enginemen, and the proprietor appearing to be perfectly ignorant of it himself.

The Chairman enquired if Mr. Smith could assign any cause for the explosion.

Mr. Smith was convinced that the water in the boiler had become too quickly heated; which no doubt was one of the principal causes.

Mr. Cowper enquired if there were any stays to the flues.

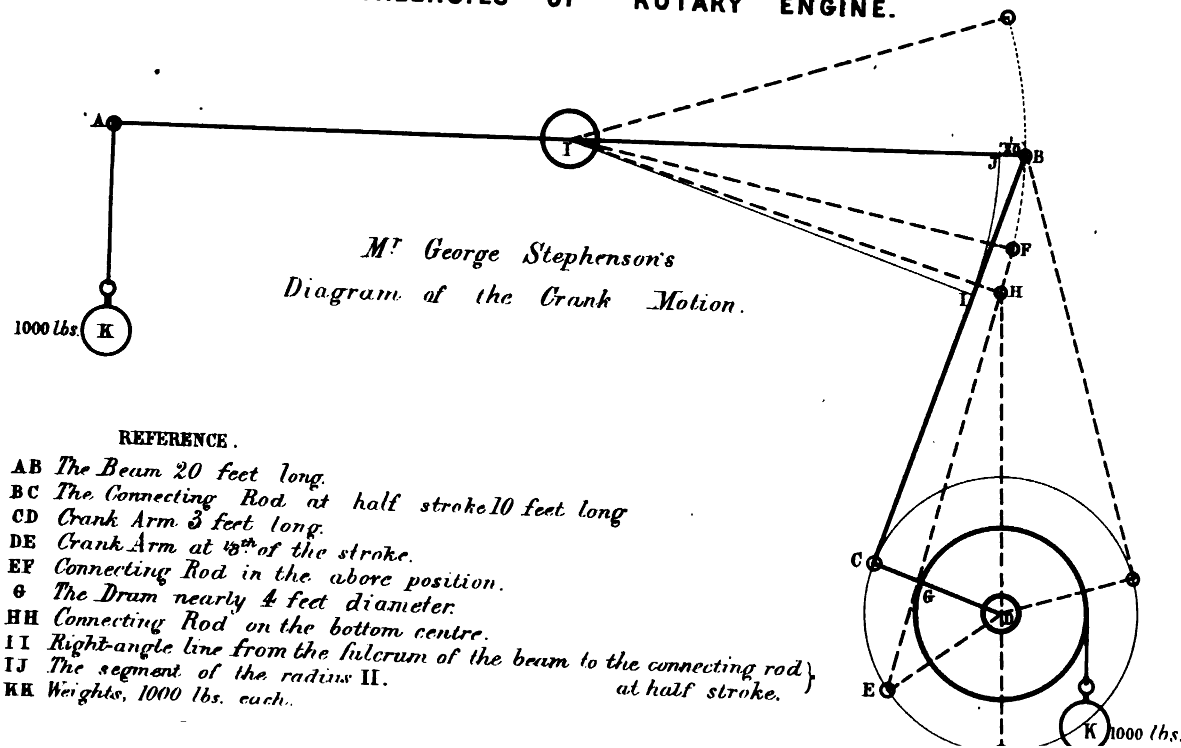
Mr. Smith said there were not, although the engine was working at 45 lbs. pressure. He was of opinion that the boiler was not at all adapted to work high pressure steam; it was on too large a scale, and there are many such in the neighbourhood of Dudley, but used chiefly for condensing engines. As near as he could ascertain, the boiler in question had been working at about 45 lbs. to the inch; which is quite a general thing in the neighbourhood. In fact many engines are being daily worked there in a highly dangerous manner, and he felt strongly that, for the safety of the public, some general superintendence should be established. It was most unsafe to allow matters to continue as at present.

A vote of thanks to Mr. Smith was unanimously passed, and the meeting terminated.

FALLACIES OF ROTARY ENGINE.

Plate 2.
To face page 1
July 1848.

Mr. George Stephenson's
Diagram of the Crank Motion.



REFERENCE.

AB *The Beam 20 feet long.*
BC *The Connecting Rod at half stroke 10 feet long*
CD *Crank Arm 3 feet long.*
DE *Crank Arm at 1/8th of the stroke.*
EF *Connecting Rod in the above position.*
G *The Drum nearly 4 feet diameter.*
HH *Connecting Rod on the bottom centre.*
II *Right-angle line from the fulcrum of the beam to the connecting rod at half stroke.*
IJ *The segment of the radius II.*
KK *Weights, 1000 lbs. each.*

PROCEEDINGS.

26 July, 1848.

The usual General Meeting of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Wednesday, the 26th of July, 1848; George Stephenson, Esq., President, took the Chair at four P. M.

The Minutes of the previous Meeting were read by the Secretary, Mr. Kintrea, and confirmed.

The President said that the first paper to be read according to the programme would be his own, "On the Fallacies of the Rotary Engine;" and having alluded to the model of a rotary engine before the meeting, by Mr. Onion then present, he invited the fullest discussion on his paper and on that model. He would show that no power was either gained or lost by the crank; and that in effect it was precisely the same as a simple lever. He then exhibited a diagram explanatory of his views; and read the following Paper:—

ON THE FALLACIES OF THE ROTARY ENGINE.

As all levers give out their powers at right angles to their fulcrums, it will be seen that the right-angle line I I (referring to the accompanying diagram), from the connecting rod to the centre of the beam, will be the true measure of the length of the beam, when the crank is at half stroke; therefore 1-20th of half the length of the beam will be gained by the piston end of the beam. The crank being 3 feet long, the up and down stroke of the piston will be 12 feet; the crank pin will of course have passed through a space of nearly 19 feet.

Now a weight hanging upon the drum, which is nearly 4 feet in diameter, will balance the same weight on the piston end of the beam; each will move at the same velocity, and pass through the same space in the same time.

It will be observed that from C to D is a little more than one third longer than from G to D; it will therefore be seen that the weight at the piston end of the beam has a little more than one third advantage over the weight at the drum. And it will also be seen that from C to E is half way from half stroke to the bottom centre; at this portion of the stroke the leverage of the crank will be nearly 2 feet. The increased power that existed in the crank from half stroke to this point will gradually be lost from E to H: it is therefore clearly proved that no power is lost by the crank motion, as the weights resolve themselves into a simple lever. There will be a little loss of power when the engine is turning the centres, which is compensated for at the connecting-rod end of the beam by the segment of the right-angle line I I.

Now a rotary engine can only give out its power on the arm, like any other lever; and if the piston passes through a space of 19 feet, it will just balance a weight equal to the same power passing through the same space.

The PRESIDENT went on to observe that the fallacy of Mr. Onion's principle was pretty conclusively proved by the fact that fifty patents at least had been taken out for rotary engines, every one of which had failed. No man who ever lived could improve on the lever principle, as there was no power but in the lever. He would now be glad to hear the opinions of the members, and also any explanation that Mr. Onion might wish to offer.

Mr. ONION then stated that his engine had been working for some weeks at the Derby station by permission of Mr. Kirtley, the locomotive superintendent of the Midland Railway; and during that trial experiments with his and another engine had proved that his

effected a material saving in fuel. A statement to that effect, authenticated by Mr. Kirtley, was now in the possession of Mr. McConnell, at whose suggestion he attended that meeting.

The PRESIDENT said that it appeared to him to be impossible that such could be the case. The engine might have answered at one trial, but it might fail at the next; and one trial was by no means a sufficient proof.

Mr. SLATE observed that there was one important desideratum which he desired to see obtained in the rotary engine, namely some method of packing tightly. That had never yet been found. He had paid much attention to the rotary engine, and had seen approaches made to an efficient system of packing, but none had been so perfect as to render the rotary principle equal to the crank. Mr. Onion had told them that his engine was more simply packed than the common engine, and he should like to have that made quite clear to the meeting.

Mr. ONION said that Mr. Scott Russell, who had written on and patented several rotary engines, confessed to him that he (Mr. Onion) had succeeded in overcoming difficulties which had hitherto been found to be insurmountable; such as making his engine steam-tight, and also doing away with the usual noise of the rotary engine. He was satisfied that his engine would bear a comparison with one upon any other principle.

Mr. JOSEPH MILLER said that one great advantage of the rotary engine, supposing it to be thoroughly efficient, was the small space which it occupied. If it were made as perfectly tight as the ordinary engine, admitting that tightness was one of the advantages of the common crank, a useful result would be accomplished. He had never yet seen a rotary engine rendered sufficiently tight, but he would not go the length of saying that it could not be done. As a practical man however he saw great difficulties in the way. He had never seen a rotary engine which remained tight for any length of time; and he should as soon expect to discover the perpetual motion as to make one which would.

The PRESIDENT observed that if he believed there was anything in Mr. Onion's engine he would be very happy to give his assistance

in bringing it before the public; but he really could not see anything of value in it.

Mr. Miller thought that the question of the crank and the rotary engine ought now to be finally settled. It was very desirable that that should be done.

Mr. Henry Robinson, on being referred to, said that the Government had a rotary engine (Lord Dundonald's) working in the Portsmouth dockyard for the last seven years. Mr. Onion claimed the credit of being the first who had ever succeeded in packing efficiently; but it was only the same packing as he (Mr. Robinson) had been in the habit of using for years; Mr. Onion had not therefore advanced anything at all new. If Mr. Onion would call upon him in London, he would show him an engine similar to his own, and packed in the very same way. It was one that was applied to a locomotive, and commonly known as the "Jim Crow" engine, from its having been painted black. The difficulty with rotary engines had hitherto been in keeping them tight. The difference between Mr. Onion's engine and the one at Portsmouth dockyard was that in the latter the packing did not depend upon springs. All that he (Mr. Robinson) was prepared to say about that engine (Lord Dundonald's) was that it had hitherto done the work which it was intended to do.

The President asked if any member was of opinion that there was a loss of power by the use of the crank. They had heard his reasons for asserting that there was no loss; and he wished that those who entertained a contrary opinion should declare it.

A Member having spoken of Beale's rotary engine, the President stated that he had been concerned in having a trial made of that engine in a steamboat intended to carry passengers a short distance of only half a mile, to Yarmouth; but when the engine was put to work he could not get the boat to move forward, and so the experiment failed. He managed to get the boat to sea, and it cost him and his party £40 to bring her back again. As to Lord Dundonald's engine, he was invited on one occasion to see it tried on the Liverpool and Manchester Railway; but he refused to go, because he was convinced that a failure would be the result; and so

it was, for the engine could not be made to draw a train of empty carriages.

Mr. Robinson :—But I think you will agree with me that there is no loss of power consequent upon the principle of the rotary engine.

The President :—Not if you make it tight.

Mr. Robinson :—The object of the rotary engine is to economise space and power; and if we cannot attain that end, there is something wrong in the mechanical means which are made use of.

Mr. Benjamin Gibbons said that the only difficulty with the rotary engine was to keep it tight; but after trying many experiments to overcome that objection he had never succeeded.

The President then called on Mr. William Buckle, who read the following Paper; having first premised that he had chosen the subject in order to give variety to the proceedings.

ON A MACHINE FOR PREPARING BONE MANURE, &c.

The object of this communication is to endeavour to direct the attention of agriculturists to the usefulness of a machine for preparing Bone Dust, which has been found to be a most valuable manure. The machine is alike available to improve the nobleman's estate or the peasant's cottage garden. An ash plant, an iron bar, a pebble from the brook, and a hand sieve, furnish a bone mill for all that a peasant requires. The arrangement of this machine reduces bones to a state of meal, and thereby prepares them for a rapid change into a state of solubility; the rapidity of the effects of phosphate of lime on the growth of plants depending upon its greater or less solubility. In all other mills I have examined, their construction merely provides for crushing the bones into lumps,

which when laid on the land in that state remain many years undecomposed, producing meanwhile little benefit to the crops.

In the year 1833 my attention was directed to this subject, the steward of a large estate in Oxfordshire having requested me to construct a mill to grind bones as fine as could possibly be done; as he found in practice that the bones prepared in the usual manner were of little benefit. He also objected to the usual method of boiling the bones before they were crushed by the rollers. I accordingly constructed a mill, which was driven by two horses, and which succeeded so well that I was requested to increase its power and to work it by a water wheel of three horse power. The first crop of turnips averaged for each turnip 47 inches in circumference and 32½ lbs. in weight, produced from seed of the red round turnip, received from Messrs. Drummond and Son of the Agricultural Museum in Stirling. They were sown in May, and produced as above in October.

In the year 1839 I constructed a bone mill, which was erected on an estate in Surrey. It was driven by a water wheel, 13 feet in diameter and 4 feet wide; with additional conveniences to the first one. After a careful course of experiments had been gone through, I received a letter from the proprietor of the estate, of which the following is an extract:—"I am much obliged by all the attention you have given to my bone mill, with the performance of which I am entirely satisfied; and I hope something may bring you towards London, that I may have an opportunity of showing you how complete a work of the kind I have; indeed I know of nothing to compete with it for such a purpose; and the manner of letting the water on to the wheel renders the whole so safe and secure, that I have yet to learn how we could do better. Melville (the millwright who has erected the mill) has prepared himself with experiments in all ways, so as to answer such enquiries as you may make; and being thus fortified, I will not trouble you with any detail, but merely state that we produce 13 bushels of fine dust per hour, and that 17 bushels of fine dust appears to be the product of ½ ton of raw bones. Thus we shall be able to produce 136 bushels of dust from 4 tons of raw bones per day of ten hours."

ıine represented in the drawing before the
ıced several additions and improvements,
former ones. The position of the stampers
by experience; and the elevators are an
ılness, as by them are lessened the duties of
ıly care is to admit water on to the wheel, to
of rough raw bones is ample, and that
is working satisfactorily. The rough bones
e heaped together in a shed adjoining the
should be made to slide down an inclined
per trough. The middle stamper is recom-
than the outside ones, to enable it to break
es; those pieces pass on in the trough, from
r; and by the time they have reached the
e reduced into meal. The meal then passes
ıders, which are placed on a descent, and
e the fine dust or meal through the wires;
om the end of the cylinders into a box, from
he elevators, and descends into the stamper
fine enough to pass through the wire meshes
ine. I also recommend the application of
ıg the ground bone dust from the bins or
the wagons, to be by them conveyed to the
ery.

of those farmers in Oxfordshire who use this
much old turf as they can from the sides of
edges, and other places where they can find
urnt to ashes. The ashes are then screened
dust, in the proportion of 8 to 10 bushels
20 to 100 bushels of burnt ashes, according
land they are working. This mixture is put
of a drilling machine constructed as an
mill, and the seed into the second or break
his means both sown at the same time, the
he brushes at the after part of the machine
up the work to be done. Should the season

prove favourable, the crop will be abundant. An intelligent and practical farmer informs me that 12 bushels of bone dust, each 66 lbs., were considered a good dressing for an acre of land, and equal if not superior to 12 tons weight of stable or farmyard manure; that the finer the bone dust is prepared, the sooner it will be changed into a liquid state, and only in that state would it, or any other manure, benefit the land; and that bones prepared in the usual way remained unchanged in the land, with little benefit to the crops.

As intimately connected with the subject of my paper, I may perhaps be allowed to allude to the surprising improvements which steam power has effected in agricultural science. To Professor Liebig of Giessen, the leviathan in chemistry of the present century, is the world greatly indebted for his deep and valuable researches in art and agriculture. He shows satisfactorily that agriculture is both a science and an art. The knowledge of all the conditions of the life of vegetables, the origin of their elements, and the sources of their nourishment, form its scientific basis. From this knowledge we derive certain rules for the exercise of the art: the principles upon which the mechanical operations depend, the usefulness and necessity of these for preparing the soil to support the growth of plants and for removing every obnoxious influence. No experience drawn from the exercise of the art can be opposed to true scientific principles; because the latter should include all the results of practical operations, and are in some instances solely derived from them. Theory must correspond with experience, because it is nothing more than the reduction of a series of phenomena to their last causes.

The vast improvements which have taken place in Cambridgeshire and the Bedford Level may be traced to three primary causes:—firstly, the improvement in the rivers which pass through the Level, consisting in strengthening their banks, deepening their beds, and particularly improving their outlets to the sea; secondly, the substitution of steam engines for draining, in lieu of the old wind mills; thirdly, the introduction of "claying," now universally practised

here the clay can be obtained. On each of
e leave to make a few brief remarks.
which traverse this Level, from the uplands
are confined to their channels by banks or
varying in height according to the elevation
nd they are intended to protect. In times of
e quantity of water comes from the high lands,
filled almost to their summit, and the stream
t a height of 10 or 12 feet above the surface
untry. Originally those banks were formed
r earth as was obtainable in their immediate
stly of silt or peat, too porous and too light to
he flood; hence they frequently gave way and
s were the consequence. They are now much
oved by repairing them with better materials,
n boats at much expense and labour. Many
red from leakage by having a wall of puddled
deep along the centre.

nent of this century, the outfalls of those
in such an obstructed state, from the loose
into them by the tides, and particularly from
uitous channels through which they had to
ssible in times of heavy rain in the uplands
which had to traverse the Level to the sea;
nd inundated districts were of frequent and
To remedy these evils, a cut or drain at the
near Lynn, called the Eau Brink Cut, after
plation for centuries and largely encountering
ll great improvements from the hostility of
e, was opened I think in 1818. By narrowing
g the course of the river nearly five miles, and
fting sands which choked the old outfall, this
d of immense benefit to the middle and south
Level. In short no serious cases of broken
have happened since its completion. Great
lso been made in the beds of those rivers by

means of the steam dredging engine; which, by removing hard substances, by deepening shallow parts, and by removing other obstructions, so as greatly to increase the scouring effect of the current, has tended very much to the efficient draining and preserving of the Level.

The application of the steam engine to drainage purposes was the second great step in the improvement of the Bedford Level. Under the old system of drainage by means of wind mills, it frequently happened that, after a great fall of rain accompanied by high wind, a dead calm of several weeks' continuance would succeed; during which time the mills were entirely useless, and the water often overflowed the land in the interval, destroying the crop, and rendering its cultivation, particularly with winter grain, a very precarious and often a ruinous venture. But, thanks to the conceptions of James Watt and the creations of Soho, our fen farmers can now commit the autumnal seed to the ground with as much confidence as their neighbours of the surrounding hills; and can hear the rains rattle against their chamber windows, through the long winter night, undisturbed by a dream of seeing their wheat lands under water in the morning, a dream which often broke the rest of their fathers and awoke them to witness its ruinous realities. The wreaths of smoke issuing from the tall chimneys of the fen-man's steam engines, like the rainbow to Noah, are hailed by them as a pledge and promise that the waters shall no more become a flood to destroy the fruits of their labours and blast their harvest hopes.

The third and crowning step in the scale of improvement was the introduction of the process of "claying," which took place about twenty years ago. It must be understood that the original surface of the land, from some unknown convulsion of nature or geological disruption, is at present very different from what it formerly was; as the evidences of its having once been high and dry land abundantly testify, in the sylvan remains so frequently found, consisting of fine oak and other trees, the horns of deer, the teeth of wild boars, and bones and relics of other forest animals. Since this era it must have been overflowed by the sea, as it is

covered, in many places to the depth of several feet, with a marine sediment of silt or clay; the deposit exhibiting both those qualities in different places, with all their intermediate mixtures, from the finest warp of the colour and consistence of mercurial ointment for sheep, to silt as raw and quick as can be found on the sea shore at the present day; and all impregnated more or less with saline properties, indicative of their marine origin.

The present surface of the Level consists, to the depth of several feet, of a black peat or moor formed entirely of decomposed vegetable matter, which has accumulated during the course of a long succession of ages, from the abundant aquatic vegetation which grew up and rotted down, year after year, on the surface of the watery waste. This peat is mostly unmixed with the clay above mentioned, over which it forms a distinct superincumbent stratum. From all this it appears that the sea must have been excluded during the period of its formation. It must also have been partially dry at different eras of its history, as it abounds with the remains of soft-wooded trees, such as willow, alder, birch, &c., which all lie between the clay and the present surface, in all stages of decomposition. The peat stratum varies much in depth in different localities, from 2 feet or less to 12 feet or more; depending in a great measure on the drainage it has undergone since. Where the water is kept out of it by draining, it subsides and loses bulk very fast, rendering it necessary every few years to lower the dip of the water-wheels of the wind mills or steam engines employed in draining it.

It will readily be conceived that a soil so light and porous as this must necessarily, when drained sufficiently for cultivation, require some heavier mixture to render it more compact and adhesive than it naturally is; particularly when exposed by frequent ploughing to the evaporating action of the sun and wind. That desideratum is abundantly supplied in the rich bed of clay underlying it, in most instances at such a depth as to be practically available for this purpose. The process of "claying," as it is technically termed, is entirely manual, and may be briefly described as follows. The land intended to be clayed, after being properly cleaned and prepared, is measured out into parallel "stetches," from 12 to 16 yards wide, by

a ploughman, who draws a furrow where every clay "dyke" is intended to be. The "clayer" commences operations at one end of the furrow, and marks out an oval, about 3 feet by 6 feet; and from this space proceeds to dig out the peat, which he casts out *before* him, continuing to cast out spit after spit in depth, till he comes to the clay. The clay is thrown out on *each side*, in equal heaps, till each heap contains about a cubic yard in quantity: this is the process for the first hole. A space of 2 or 3 feet is left, and a second hole commenced, the peat out of this hole being thrown into the first, and the clay on each side as before, nothing but the clay being left on the surface. The peat out of each hole being cast into the preceding one, the heaps of clay are spread over the land in the same way as manure, and all the surface as equally covered as can be. The fertilising effect of claying on soils previously exhausted and almost worthless is astonishing; the produce being frequently from 5 to 6 quarters of wheat and 10 quarters of oats per acre. It is common to take two or three "white crops" in succession without any manure; and the land is permanently benefitted ever after. The general practice is to clay the land in winter or early in spring for oats; after which the land is sown with wheat in autumn. The land clayed in summer is mostly sown with cole-seed, and fed off or ploughed in autumn for wheat, which is not found to succeed so well on clay raised in autumn, as it is supposed to make the land too cold for the young plant in the succeeding winter, should the weather prove severe. The expense of claying ranges from £2 to £3 10*s*. per acre.

The introduction of claying has quite revolutionised the agriculture of the fens. The old course, before the adoption of steam drainage and other improvements for the security of winter crops, was to pare the surface in May or June, with a plough adapted to that purpose, having a broad share, kept very sharp by the frequent use of the file, to the depth of about 2 inches: after exposure to the sun for two or three days, the furrows or "flags" were cast up into heaps and burnt, the soil being of such a combustible nature when dry that it was soon reduced to ashes; and these ashes, when spread over the land, ploughed in, and sown

with colewort, produced grass on which to feed sheep in the following winter, the land being sown with oats in the following spring. A second crop of oats was sown the succeeding year, and the land "laid down" with rye grass for two or three years succeeding; when the same course of burning and cropping was repeated, without any other manure than the ashes and that left by the sheep which fed off the green crop. When it became practicable, by means of improvements in the drainage, &c., to raise wheat crops, the process was the same. This system was considered the *ne plus ultra* of fen farming for several years; but it proved a very exhausting process, as the repeated burnings destroyed too much of the staple of the soil: the diminished crops of the ashes became weaker at every repetition of the process; diminished crops of colewort gave less and less animal manure to the land: and the system was fast wearing itself out, when claying came to the poor fen-man's rescue, and a new era commenced in fen farming, which has completely superseded the old system, and introduced in its place what can be called no system at all, as there are now no regular courses or rotations of crops. The land is now almost universally under the plough; and when crop-sick with white corn, it is renovated with green crops of colewort, swede turnips, &c., drilled in with bones, rape cake, guano, &c.; but chiefly with bones, which are used to a great extent.

Mr. Cowper asked what was the shape of the stampers; they appeared to be in the form of a cross.

Mr. Buckle replied that the form was that of an inverted cross.

Mr. Cowper:—And the weight of the stampers?

Mr. Buckle:—The centre one is 4 cwts., the next 3 cwts., and the outside stampers $2\frac{1}{4}$ cwts. each.

Mr. Henry Robinson:—What is the height of the stroke of the stampers?

Mr. Buckle:—Sixteen inches.

Mr. Cowper:—At what speed do they go?

Mr. Buckle:—Forty blows per minute. The power is rather under three horse power; but the ordinary mills with rollers require from fifteen to twenty horses to do the same work. All know that a very heavily laden wagon might pass over a leg of mutton bone without having any effect upon it, while a smart stroke from a knife would be sufficient to break it; and I kept that fact in view in constructing my machine.

Mr. Cowper:—Then you mean there is a saving of 80 per cent. from not using rollers?

Mr. Buckle:—I do.

Mr. Gibbons:—It appears to me that the principle of this machine is that the *breaking* force acts, by division, upon several points; instead of concentrating all the power to *crush* upon one point, as is done by the roller system.

Mr. Buckle:—Precisely so.

The President then requested Mr. William Smith, of Dudley, to read the following Paper:—

ON HIGH PRESSURE STEAM BOILERS, AND ON BOILER EXPLOSIONS.

At the last meeting I laid before the Institution a tracing and description of the steam boiler which recently exploded near Dudley; and although time did not permit any discussion as to the merits or demerits of the construction of that boiler, I think it is very evident that boilers of similar formation and dimensions cannot be safely used for high pressure steam, say 40 to 50 lbs. per square inch. I make this assertion because the great diameter

of the outer shell renders it very liable to be torn asunder by the internal pressure; the internal vertical flue being also of such dimensions that it may be forced out of form and suddenly collapsed by external pressure: and if that system of boiler were to be made safe by a large reduction of the diameter, it would make them insignificant in capacity of heating surface and generating power, and consequently unfit for the purpose they are intended for, namely to use the great quantity of waste heat which escapes from puddling furnaces.

I have prepared the accompanying drawing of a boiler which I recommend in preference to those on the above principle; being much better adapted for generating and for safely containing high pressure steam; and I think more convenient in every other respect for the above system of heating. Fig. 1 is a sectional plan through the boiler, showing four puddling furnaces as I propose placing them to act upon it. Fig. 2 is a longitudinal section through the boiler and descending flue to the chimney. Fig. 3 is a longitudinal elevation of No. 2, with the side view of a puddling furnace at one end, and a section through one at the other end. Fig. 4 is a cross section through the boiler and two furnaces. Fig. 5 is an end view of the brickwork &c.

The boiler is 32 feet long and 4 feet 9 inches in diameter; with two tubes or flue pipes under it, each 36 feet long and 1 foot 8 inches in diameter, and attached to the boiler by three vertical pipes, 10 inches in diameter. The flue pipes are made in a bent form, so as to be highest at the middle and drooping to each end, to keep circulation in the water. The drawing will sufficiently explain every other particular connected with this boiler, so that further description is unnecessary. I shall therefore now only point out a few of the advantages it possesses over the description of boiler before referred to.

Firstly, the diameters of the cylinders being small, they may be made of much thinner plates, and still be perfectly safe with a greater pressure of steam.

Secondly, the heating surface is large and concentrated, without winding flues, so that much steam will be generated.

Thirdly, the area of water surface being much larger, there will be less difficulty in maintaining its proper level.

Fourthly, the steam and water space and heating surface harmonise in their proportions.

Fifthly, the great facility for cleaning out. This is an object of the first importance in the construction of all kinds of steam boilers; as it is well known that, where any difficulty exists in performing that operation, the chances are that it will either be imperfectly done or left undone altogether; which is one cause of many of the fatal explosions that so frequently happen with land boilers.

I do not wish to enter at any length on the theory of explosions; but merely to state my conviction that to one of the three following causes are to be attributed all the accidents to steam boilers:—first, malformation for the working pressure and quantity of steam required; second, want of proper care to fit every boiler with proper steam and water indicators; and third, neglect of cleaning out at proper times. It is a lamentable fact that many boilers extremely liable to accident from one or other of the above causes are still in use; and I think the following reasons will to a great extent account for so bad a state of things existing, in a country too where so much engineering skill may always be procured to rectify defects.

Respecting malformation, I would state that persons about to make erections for steam power generally make the first outlay of capital a leading consideration; and consequently cramp the dimensions of their engines, so that the engines are just calculated to do the work required, with nothing to spare. Soon however some extra machinery is introduced into the establishment; and the engine being found defective in power with the original pressure, an extra load is immediately put upon the safety valves of the boiler; and this process is repeated time after time, as each little additional machine may require the extra power. It follows that the boilers which were prudently arranged to do the work in the first instance are at last a malformation for the increased pressure, and

therefore work in a highly dangerous state; whilst the unsuspecting operatives may be seen crowding round to warm themselves at meal times, when the danger is probably greatest.

Then as to defective steam and water indicators, I have always observed that land engine boilers are not so efficiently fitted with these instruments of safety as marine and locomotive boilers; although I think it is very necessary that they should be so, seeing that a number of them are frequently left to the charge of one individual, with other duties requiring much of his time and attention: whereas the indicators of marine and locomotive boilers are constantly under the eye of one or more engineers, of well proved character and ability for the duties required; and moreover engineers of a higher class are always resident at the principal stations, invested with power to examine engines and to inspect the whole machinery periodically. I have shown on the accompanying drawing all the indicators which I consider necessary for a high pressure boiler in ordinary circumstances. They are as follow:— one feed cock or valve, one float water-gauge with stand and wheel and counterbalance, one glass water-gauge, one steam whistle also for a water-gauge, and two safety valves, one of them locked up. For low pressure boilers I think the open-top feed-pipe, with open pipe for the float wire to work through, is a very perfect apparatus to prevent the steam from rising too high or the water from getting too low.

Respecting the keeping of boilers clean, I have seen that process very imperfectly performed and often altogether neglected in establishments where a sufficient number of spare boilers are not provided and where there is no time to have the boiler cooled down for men to remain in it to do the work properly: but I believe that the greatest cause of neglect in this most important matter is its being generally looked upon as a thankless sort of job; the engineman always looking upon it as an extra duty for which he claims extra allowance, and the master considering that he pays enough to the engineman for that and his other duties. The results consequent upon inattention to boiler cleaning require no comment here; and every practical engineer knows that, if actual

explosion does not happen, the wear and tear upon those parts most exposed to the fire must be greatly increased, thereby keeping up a heavy expense in repairs, independent of the immense quantity of extra fuel that is required to keep up the steam.

I trust that these remarks will suffice to draw the attention of the members of the Institution to this highly important subject; and that the proprietors of steam power may be convinced that the small extra outlay required to make their boilers perfectly safe will be more than repaid by the economy in working.

Mr. HENRY SMITH said that one disadvantage of the plan proposed was the large amount of room which the boiler would occupy; and that space was often a great object to gain in works.

Mr. GIBBONS thought that less space would be occupied than formerly.

Mr. SMITH observed in reply that on an investigation the objection would be found not to apply to his boiler, which had something in its favour as to size over the ordinary boiler, though not much.

Mr. BUCKLE remarked that he had had frequent opportunities of observing the reckless manner in which the fitting up of engine boilers was carried on in Staffordshire, to which however there were some exceptions. The upper part of them was generally exposed to the weather, a system which in most cases was attended with ruinous loss. He thought that it would tend greatly to lessen the number of those fearful boiler explosions which had so quickly followed each other of late, and would also be the means of effecting a great saving to the proprietors of the numerous ironworks in Staffordshire and other districts, if a superintending engineer who thoroughly understood his profession were appointed to examine periodically the condition of the engines and boilers employed in these works. It was to him perfectly astonishing that such immense ranges of boilers should be left completely exposed to the weather, as was often the case. In

the year 1832 he was sent for to Bilston, to superintend the renovation of an old blast engine: he had satisfactorily completed the undertaking, when, the season being that of harvest, a thunder storm accompanied by tremendous rain came on; and when he was expecting that everything was right, the engine completely stopped. He thereupon tried the safety valves of the boiler, but not a breath of steam came from them. The steam had become condensed by the exposure of the boiler to the storm; and no excuse could be offered for such gross neglect, as materials for covering were to be had quite at hand and would cost but little. He believed that a handsome fortune might be made by covering up the boilers.

Mr. Fothergill enquired of Mr. Smith whether his boiler was not what was termed a "French boiler."

Mr. Smith replied that it was; he had made them in France.

Mr. Fothergill:—Are they not apt to crack on the upper surface of the lower tube, and on that account subject to frequent complaints?

Mr. Smith:—They never have cracked to my knowledge.

Mr. Fothergill thought that there would be a tendency to crack in the upper surface of the lower tube; and also that greater wear and tear than could be anticipated would be occasioned by the exposure of the lower tube to a greater amount of heat and the action of the fire than the upper one.

Mr. Smith did not think that the tube would be liable to such an injury, because the circulation of water was kept up.

Mr. Cowper suggested the lengthening of the tube, on the principle of lengthening a chimney to get a better draught.

Mr. Smith considered that such an alteration might be an advantage.

Mr. Cowper remarked that, as a protection from the white heat of a blast furnace, there ought to be a parapet wall. He thought that the boiler would be far preferable if parts of it were covered with brickwork.

Mr. Smith said that the operation of the heat on the tube was common to other descriptions of boilers in blast furnaces; and that the operation was not greater in his than in any other case.

Mr. McConnell thought that there should be an indicator to enable the man who attended to the boiler to ascertain when the circulation between the lower and upper tube was impeded. It appeared to him that there was reason to fear that the lower tube might be deprived of water.

Mr. Smith had never seen or heard of such a thing having occurred; neither did he see that it was likely or possible. If the boiler was half filled with water, the tubes were of such dimensions, being 10 inches in diameter, that he did not see how any part could get clear of water.

Mr. McConnell said that accident had actually occurred at the salt works at Droitwich: the lower vessels from a want of circulation were deprived of water, and an explosion took place. In that case there were greater facilities for the circulation of water than were allowed by Mr. Smith. The cause of the accident was the lower vessel being deprived of water, and the consequent rapid generation of steam. Fortunately at the moment of the explosion the men were at dinner; but had it happened only five minutes before, fifty or sixty persons would have been killed; as it was, three or four only suffered. If Mr. Smith's boiler were brought into general use, some detector apparatus should be employed, to ascertain whether the upper vessel was doing its duty by circulating the water to the other one.

Mr. Ramsbottom was of opinion that an improvement would be effected in the boiler by making the generating cylinders lowest in the middle, and inverting the direction of the circulation by having the descending current in the centre tube. The greater part of the steam which was generated near the ends of the lower cylinders would not then have to pass along into the centre tube, but would find its way immediately through the end tubes into the steam chamber; the circulation would therefore be much more rapid.

Mr. Smith said that he felt gratified by the various suggestions that had been made. They would induce him to turn his attention to the means of improving the boiler brought before the meeting; but he trusted they were all of opinion that it was infinitely better adapted for its purpose than those now in use.

Mr. Robinson said he should like to know whether in any case heat would injure boiler plates where there was a constant supply of water.

Mr. Cowper said he could take upon himself from experience to answer the question in the affirmative.

Mr. Fothergill said he would take leave to exhibit the drawing of a boiler which had recently exploded in Manchester, sacrificing thirteen or fourteen lives. The boiler showed such singular rents that he had been induced to have a drawing of it made by an artist; and he had purchased the boiler and presented it to the Manchester Mechanics' Institution. The drawing clearly showed the consequences of that kind of boiler getting out of repair; and he considered that the observations of Mr. Smith were most important. Every member would be satisfied that if the sacrifice of life on the explosion of a small boiler, such as he had referred to, was so serious, the result of the explosion of one of a larger class carrying a greater pressure must be fearful indeed, unless proper attention were paid to the protection of the lives of the men who had to attend to them. He was collecting particulars respecting the explosion of the boiler to which he referred; and he intended to lay them before the Institution at some future meeting.

Mr. Gibbons said that, in the cases which had been referred to, the explosions would have been guarded against by a simple indicator like the following:—a gas pipe of any diameter inserted through the top of the boiler down to a safety line in the water, to be acted upon by hydrostatic pressure, so as to show the pressure of the steam and also any deficiency of water in the boiler; these being the two causes from which explosions of high pressure boilers principally arose. This indicator might be of any diameter, say $1\frac{1}{2}$ inches, to be open at both ends, affixed to the engine chimney, and lengthened upwards to whatever height the pressure of the steam in the boiler might require; calculating 2 feet of perpendicular height for every lb. of steam pressure per square inch. Suppose the water to get below the safety line, the steam would rush out at the top of the pipe; and suppose the safety valve to be overloaded or not to act, the water would be ejected at the top, thus giving an

instantaneous alarm to the engineer and workmen. The cost of the whole thing would be very trifling; it could easily be applied, and would not be liable to get out of order.

The PRESIDENT remarked that the suggestion of Mr. Gibbons was not new, for such a pipe had long been known as the alarm pipe.

Mr. GIBBONS considered it was desirable that its utility should be more generally known.

On the motion of Mr. McCONNELL a vote of thanks was unanimously accorded to Mr. Smith for his valuable paper.

The following Paper, by Mr. Charles De Bergue, of London, was then read:—

ON A STATION AND COLLISION BREAK APPARATUS.

The subject to which this paper refers is an improved apparatus intended to act as a Station Buffer or Break, for arresting the impetus of any engine or train that may have entered a station at too great a velocity. It is also proposed to apply the same to luggage vans accompanying trains, in order to lessen the injurious effects of collisions on railways; but first it will be more particularly referred to as a station buffer.

To render a station buffer as effectual as possible, it should combine the four following conditions:—

Firstly, it should move through as much space as, in the arrangement of the machine, is consistent with moderate proportions and economy.

Secondly, its power of resistance at the commencement of the stroke should be rather under the average amount that will drive home the ordinary carriage buffers; say about 3 tons.

Thirdly, its resisting power should be made to increase gradually through the whole range of action, so that before the stroke is quite completed the resisting force should be nearly as much as the under-frames of the carriages would be able to bear without breaking or collapsing; probably from 12 to 16 tons.

Fourthly, it must not have any recoil action after being driven up.

Supposing a train, with a momentum equal to 100 tons moving through 1 foot of space, to come in contact with a station buffer, it would be requisite, to enable the station buffer to arrest the impetus of the train, that the resisting power and the length of the stroke should be in proportion to each other. A station buffer having but 1 foot of action would require a resisting power of 100 tons to arrest the above train; but in this case the carriages would be smashed by the collision: yet if the station buffer were made to move through a space of 10 feet, then a uniform resistance of 10 tons would suffice to arrest the train; but, although in this case a resisting power of 10 tons at the commencement and throughout the stroke might not actually cause the carriages to be smashed, the passengers would receive so severe a concussion that the consequences might be equally disastrous. If the resisting power were made to commence at 3 tons, and were kept progressing in such a ratio throughout the 10 feet, without exceeding 16 tons at the end, that the average resistance would still be equal to 10 tons moving through 10 feet, the train would then be brought up without sustaining any damage. This would be the maximum useful effect that could under any circumstances be produced by a station buffer having a 10 feet stroke with a resistance ranging between 3 and 16 tons. The resisting power of such a buffer would be equal to 1 ton through a space of 100 feet, or to 100 tons through 1 foot; and its power may be increased or reduced by increasing or reducing the length of stroke.

This is the result which has been sought to be obtained by arranging this buffing apparatus, a working model of which is now before the meeting. It is made to a scale of one-eighth full

size; its power and weight are as the cube or as 1 to 512. It represents a strong under-frame of a railway carriage, supported as is customary on wheels and axles. The buffer rods are in the same position as usual, but are much longer and larger in diameter: they are intended to be made of welded wrought iron tubes, 3½ inches in diameter, for obtaining strength without too much weight. They stand out 4 feet at each end of the carriage, and terminate inside in wrought iron racks, the teeth of which are cut out of the solid. These racks must be made of a suitable breadth, and with a pitch of sufficient strength to resist the maximum power they are intended to sustain. The racks of one end of the carriage are turned with their teeth upwards, and those of the other end with their teeth downwards; and they are placed so as to admit the passage between them of the pinions which gear simultaneously into the two racks. A strong wrought iron transverse shaft or axle passes directly across the centre of the carriage, being fitted in bearings in the side beams. On each end of this shaft a wrought iron pinion is formed, which should be forged in one piece with the shaft, the teeth being afterwards cut out of the solid, in order to render them sufficiently strong for the purpose. A friction drum is securely keyed on the centre of this shaft; this drum is surrounded by two steel friction belts, which take about a turn and a quarter round it, being made fast at one end to one of the cross stays, while the other ends are attached to the vertical arms of two levers, the other ends of these levers being subject to depression by the action of two small springs, which are so arranged that when the apparatus is put in motion the pressure on the ends of the levers increases in proportion as the buffer rods are required to oppose greater resistance.

As the model will be readily understood by the members of this meeting, it will be useless to give a minute and tedious description of it; a few general observations will therefore suffice. It will be observed that the principal feature about this invention consists in producing the resisting power of the buffers by means of a friction break, so combined as to effect an increasing amount of resistance throughout the range of the stroke; and that, as this resisting power is effected by mechanical means, it is susceptible of being

modified almost to any extent, as regards its length of stroke and amount of resistance during its range of action; and that it possesses the great advantage of having no recoil.

The model before the meeting is intended, as the under-frame of a luggage van, to be placed between the back of a tender and the carriages composing a passenger train, or at the back of a train on foggy nights, in the event of another train running into it. This model represents 8 feet of stroke for the buffers; supposing the resisting power to average only 10 tons, it would be equal to destroy a momentum of 1 ton through 80 feet, or 80 tons through 1 foot. This would be a considerably more effective buffer than any station buffer now in use. It may be presumed, if a good and powerful buffer could be of any use in a station, that this apparatus must be of some service in a train in the event of a collision; especially when it happens, as it frequently has done, that the speed of the train has been very considerably reduced before the collision actually takes place.

It is intended to make several modifications in the model for its special application as a station break, and particularly to give it more length of action.

Mr. De Bergue at the request of the President explained the construction and action of a model carriage fitted up with his apparatus. It was then resolved to postpone the consideration of the subject until the next meeting.

The President stated that several meetings of the Committee of Council, appointed to alter and amend the Rules and Bye-laws, had been held; and that the result of their labours would in a short time be submitted to the Members for their approval.

The Ballot Lists having been opened, it was announced that the following gentlemen had been elected Members and Honorary Members :—

MEMBERS.

W. A. Adams, Midland Works, Smethwick, near Birmingham.
John Bourne, Engineer, 11 Savage Gardens, London.
Frederick Braithwaite, 9 Adam Street, Adelphi, London.
John Braithwaite, 39 Bedford Square, London.
David Burn, Busy Cottage Iron Works, Newcastle-on-Tyne.
Edwin Clark, Assistant Engineer of the Conway and Britannia Tubular Bridges, Conway.
Robert Daglish, Jun., Messrs. R. Daglish Jun. and Co., Engineers, St. Helen's, Lancashire.
J. R. Davidson, Aberdeen Railway, Drumduan, near Aberdeen.
Isaiah Davies, Engineer, 44 Bromsgrove Street, Birmingham.
William Denny, Messrs. Denny Brothers, Iron Ship Builders, Dumbarton.
Peter Fairbairn, Messrs. P. Fairbairn and Co., Wellington Foundry, Leeds.
Alexander Fulton, Lancefield Forge, Glasgow.
Thomas Gibbins, Manager of the Battery Company's Metal Works, Digbeth, Birmingham.
Thomas Greenwood, Wellington Foundry, Leeds.
William Hamer, Carriage Builder, Leicester.
Richard Harrison, Engineer, Leeds.
William Hawthorn, Locomotive Engine Works, Newcastle-on-Tyne.
William W. Hewitson, Messrs. Kitson and Co., Airedale Foundry, Leeds.
S. C. Homersham, Consulting Engineer, John Street, Adelphi, London.
Alfred S. Jee, 6 John Street, Adelphi, London.
John Kirkham, Engineer of the Imperial Gas Works, 3 Tonbridge Place, Euston Square, London.
James Kitson, Messrs. Kitson and Co., Airedale Foundry, Leeds.
J. Leather, Engineer, Leventhorpe Hall, near Leeds.
Thomas W. Lord, Messrs. Lord and Brook, Machinists, Leeds.
Walter F. MacGregor, Vauxhall Foundry, Liverpool.
M. McPherson, Marine Engineer-in-Chief to the Emperor of Russia, St. Petersburg.
D. C. Mudie, Messrs. Gourlay and Mudie, Dundee Foundry, Dundee.
John Napier, Messrs. Robert Napier and Sons, Marine Engineers, Glasgow.
Walter Neilson, Messrs. W. Neilson and Co., Hyde Park Iron Works, Glasgow.
Michael Norton, Engineer, Eccles New Road, Manchester.
George H. Philipson, Engineer, 93 Pilgrim Street, Newcastle-on-Tyne.

arine Engineer, Hull.
Engineer, 1A Terrace Chambers, Adelphi, London.
gineer of the Bootle Water Works, Liverpool.
rth, Messrs. Clayton and Shuttleworth, Iron Founders, Lincoln.
, Engineer, Leeds.
r, Messrs. Stothert Slaughter and Co., Avonside Locomotive
s, Bristol.
Iron Founder, Bilston.
Messrs. Kitson and Co., Airedale Foundry, Leeds.
ngineer, Bowling Iron Works, near Bradford.
Iron Founder and Steel Manufacturer, Sheffield.
Erdington, near Birmingham.
e, Messrs. T. Wingate and Co,, Whiteinch Iron Works, near

gineer, Hunslet Lane, Leeds.

HONORARY MEMBERS.

General Manager of the London and North Western Railway,

r, Chairman of the South Eastern Railway Company, London.
Peto, M.P., 47 Russell Square, London.

PROCEEDINGS.

25 October, 1848.

ERAL MEETING of the Members was held in the
osophical Institution, Cannon Street, Birmingham,
25th of October, 1848; J. E. McConnell, Esq.,
the Chair.

f the former Meeting having been read by Mr.
ary, were confirmed.

in opening the business of the meeting, said they
irst time since the death of their late lamented
t which, he was sure, all of them deplored most
was a man who raised himself by his own talents
position in society, and whose name, so long as
ould endure. A member of Council, Mr. J. Scott
undertaken the task of writing a memoir of their
had intended to be present that evening to read
had however received a letter from Mr. Russell,
prevented his coming; it was therefore left to
ell) to read it.

NOTICE OF THE LIFE AND CHARACTER

OF THE LATE

GEORGE STEPHENSON,

FIRST PRESIDENT OF THE INSTITUTION OF MECHANICAL ENGINEERS;

Prepared, by desire of the Council,

BY J. SCOTT RUSSELL,

ONE OF THE MEMBERS OF THE COUNCIL.

I wish I could address myself to the business of this evening with a feeling that the duty which you have devolved upon me were less inevitable, or more worthily performed. We have met to deplore the loss, not merely of one of the founders of our Society, but also of a personal friend, whom we have long regarded with reverence and affection. Had these feelings of affection been alone regarded perhaps our mournful silence would have formed the most expressive exponent of our grief; but the expression of our grief is the least of our duties. In our late President, England has lost one of her most distinguished men, the world one of its great benefactors.

It is not as our President merely, standing as such at the head of the Mechanical Engineers of Britain, that the name of Stephenson will be known to posterity; he will be known to posterity as the presiding Genius of our times: for of this we may be firmly assured, that the times in which we live will be known to posterity as the era in which Railways and the Locomotive Engine were first introduced as elements of social progress. It will be recorded, that about the middle of the nineteenth century Locomotives first began to run upon Railways, and that George Stephenson, the President of the Institution of Mechanical Engineers, was the man to whose original genius chiefly the world was indebted for the discovery.

It is difficult for us, to whom the words Railway and Locomotive are household words, to us who live, move, and have our being among Railways and their manifold social results, to go back again, even in imagination, to the beginning of the twenty years ago when

we were without them. So fast indeed we may be said to have lived through these twenty years, so much we have been able to travel over and see and learn and do, that it seems longer to go back over these twenty years than over centuries of the slower times that went before. We, who have each of us this day come our hundreds of miles to this meeting, and may still have to return hundreds of miles to our homes this night, shall find it hard to believe in the records of perils, privations, and delays, which but a few years ago made a journey from Newcastle to Birmingham one of those serious undertakings of life which were anticipated with apprehension, and recollected with congratulation. We now do more work, see more society, acquire more knowledge by personal observation, in one day of railway life, than we were wont to do in weeks of "the good old time." It will be necessary however to task our imaginations, and go back to the times before Stephenson, in order duly to appreciate the full value of the benefits which his labours have conferred upon us.

It is not however alone with what George Stephenson *did* that we are concerned; still more important is it for us to consider what George Stephenson *was*. His title to our gratitude is no doubt great; but his claim to our admiration, as a man, is still greater. As a plain labouring workman we first find him distinguished by his untiring industry, by his zeal for the interests of his employers, and by his steadiness, sobriety, and honesty. We next find him, after having mastered all the details and drudgery of his business, continually on the watch for improvements, cultivating habits of accurate observation, and spending every leisure moment in classifying and comparing the results of his own observation, and in deducing from them hints for future improvement. Did an accident occur in his mine, his whole thoughts were immediately directed to the means of preventing its recurrence. His business, in the humble capacity of a breaksman, took him casually to the vicinity of a condensing steam engine, where the property of his master, through ignorance and mismanagement, was in danger of suffering serious damage. The young breaksman had already carefully studied the nature of its parts, and thought over the principles of its construction;

the regular engineer had been baffled in his remedies, and despaired of a cure; but the youthful breaksman confided in the strength of his convictions and boldly undertook the task of refitting the machine; the stubborn engine became at once, in his hands, obedient and useful; he had discovered for himself the secrets of the steam engine; and at five and twenty the young coal-worker had become a Mechanical Engineer.

Thus early were the results of his self-education manifest. He had mastered the discoveries of Watt. It is true indeed his whole life had been one of discovery; but as yet he had discovered no more than those who had gone before him. His had been the best of all education,—the education which a truth-loving mind, working its way among dead matter and wrestling with the laws of nature, receives directly from nature herself,—an education far more profound and prolific than words, books, or lectures can ever impart. He had learned the laws of nature at first hand, and by experience; he knew partially what the true properties of matter were; he felt that what they were was exactly what they ought to have been; and however indefinitely he might be able to give reasons to others for his belief, yet one of the most valuable results of his practical self-education was to give him that implicit confidence in his own right understanding of nature, which carried him so boldly through the herculean undertakings of his future life. The whole first years of his early life were, in this way, one continued chain of discovery. Who can tell the pleasure, or weigh the profit, which such an education bestows on the simple and correct student, compared to the formality of written dissertations and the dryness of second-hand knowledge.

As yet, we have said, he had discovered nothing new; but he was now on the eve of making a discovery, the reputation of which has ennobled the name of one of our greatest chemical philosophers. A mechanic, James Watt, had already anticipated the philosophers Cavendish and Lavoisier in the analysis of water; and another was now about to anticipate Sir Humphry Davy in the invention of the Safety Lamp. That Stephenson was the original inventor of the safety lamp is now happily beyond doubt. Like most other

inventions which seem to make their appearance in several places simultaneously, at the moment when the want of them has come to be deeply and generally felt, the safety lamp seems to have started into being at the same moment, nearly, in Newcastle and London. Stephenson and Davy had both discovered the principle on which they proposed to proceed, before either had made the lamp; *but Stephenson's was made and used the first.* That Stephenson first invented the lamp admits of no doubt, however much the question may remain as to how far Davy may not also be entitled to the merit of equal originality: priority to Stephenson no one can justly claim.

It is as a professional Engineer and a practical Mechanic that we here have chiefly entrusted to us to do justice to the memory of our distinguished President. But we should do violent injustice to our own feelings if we were to pass altogether without notice his social character and private life. It is well for us all to recollect, that mere eminence as mechanics, or mechanical inventors, is not enough in the social world to make us command either the love or respect of our fellows. It is as *men*, chiefly, that we respect one another; it is moral character and social virtue for which we chiefly love one another. It has indeed been remarked by some, on the character of our profession, that the continual struggle with tough, hard, and refractory substances, which forms the business of the engineer, has the effect of communicating a hardness of character, an obstinacy of disposition, and a rigidity of temper, to men of our craft, which does not add to their excellence as members of society. It must be remembered however, as a palliative for such faults where they exist, that every inventor is at first in a minority of one; all the rest of the world is, for the time, against him; and it is often only by a long and hard fight that he at last succeeds in converting his minority into a majority.

Invention is therefore a battle with the world; and it is not easy always for the inventor again to consider with complacency his enemies in the field, and to adopt them as his companions in the closet. The antagonism between the inventive man and the sceptical world is apt to extend itself to the social state. But Stephenson was, happily for himself and the world, a man endowed with no common

share of the endowments which make the intercourse of life useful to himself and delightful to his friends. His energies had been sufficient to carry him through much opposition without cooling the ardour of his affections, originally warm and genial, and above all without chilling the enthusiasm or closing the openness of disposition which characterised the sanguine youth. In his latter days he was distinguished for the childlike simplicity of his character, for the transparency of his intentions, for the singleness of his purposes, and for the straightforward manly honesty of his conversation and dealings. If he could hate an enemy, he never masked his antipathy by hypocrisy; but he was a warm and earnest friend.

Greatly however as Stephenson's name will continue to be distinguished among us as the inventor of the safety lamp and as a youthful mechanic of wonderful shrewdness and sagacity, it is as the first constructor and chief inventor of Locomotives and Railways that he will be known to posterity. It is in this capacity that he has conferred on society blessings which are rapidly extending to the widest limits of civilisation, and which already cover Europe and one half of America. The introduction of railways is the great distinguishing event of the thirty years' peace; and to them must principally be attributed the strong bonds of amity which are continually drawing nations closer and closer together; it is to railways, and the unity of international interests arising from them, that we are indebted for maintenance of that peace unbroken for thirty years, and for the very remarkable events we are now witnessing in the existence of a *casus belli* in the heart of Europe, and yet an invincible reluctance of the great powers to supply the fuel for a general war. The peace of Europe will now, we may trust, by the progress of railways and the consequent multiplication of intercourse, be rendered as substantial as the peace of the nations of the heptarchy of England; for we have nearly reached that period of railway intercourse, when the capitals of different nations of Europe are not separated so far from one another, either in the length of time or in the rarity and peril of intercourse, as were the five capitals of the Anglo-Saxon kingdoms of our ancestors:

rk, and Gloucester were then more distant than are
erlin, and Vienna.

is was early brought about, how much George
l to do with it, is now too familiar to every mind to
You all know how he early got permission from
rth and the proprietors of the Killingworth collieries
on substitute for the horses which drew his coal
he succeeded in driving teams of wagons some six
but all of you who recollect those huge unwieldy-
rs of that early time, and especially those who, like
ad to do with them, must remember how little we
ing those clumsy affairs go 10 or 20, much less 50 or
r. Indeed, whether we look at the railway or the
would have immediately been smashed to pieces had
rated their speed to 10 miles an hour. It was never
ept by one dreamer, who believed in 10, 20, 50, and
our, and who had recently determined to do it.

entions which have been combined to produce the
system may be said to be, the malleable iron rails
tive engine. These were the two elements of high
f which formed the absolute condition of the existence
Without the system of laying a continuous wrought
otion of a velocity of 50 miles an hour could not
tained: and without the locomotive engine, such an
could never have proved remunerative.

can remember when the idea of laying wrought iron
or 90 lbs. weight per yard, for continuous miles, was
utterly beyond the conception of the time, as not to
for a moment; and this for an obvious reason, that
mount of traffic would have paid for it. I think I
in saying, that no amount of traffic which horses
onvey along a line of modern railway could yield a
eturn, unless perhaps under peculiar circumstances,
eptional; I am therefore, I think, safe in saying,
ght iron railroad was essentially dependent on the
ine.

But that the modern locomotive engine could not subsist without the wrought iron rail and its multifarious appendages of chairs, keys, locks, sleepers, switches, crossings, sidings, and turntables, is too evident to need proof. Without the smoothness of the rail, the engine would be jolted to pieces; and without the easy motion which it gives, the engine could not be made to draw a sufficiently profitable load to pay: and further, unless the rail were made of wrought iron, it would be impossible to attain the high speed of the locomotive without imminent danger. It therefore appears that the continuous wrought iron railway and the locomotive engine were inventions intimately related to each other, and each a condition of the other's success. To Stephenson we are indebted for the chief features of improvement in both. It was the joint perfection of the road and the engine which created the Liverpool and Manchester line, and all the progeny of that wonderful and gigantic experiment; an experiment whose complete success now bears incontrovertible testimony to the genius of the man.

There are several lessons which the life of Stephenson should enforce upon us, the members of a profession which he advanced, and of a Society which he so materially assisted in founding, and in the promotion of which he took a constant and deep interest. Indeed we cannot cast even a hasty glance back over the events of his life, without perceiving that the foundation of our Society was an act most appropriate to the termination of a career so arduous and successful. Let us endeavour to define some of those objects, and then consider how we can best accomplish them.

In the first place, then, one of the great objects of our Society is the encouragement of mechanical invention and the promotion of scientific improvement. Thus it becomes our duty to supply to this generation a great want, chiefly felt by Stephenson in his early career. The unhappy moments of his youth were those in which his inventions encountered the opposition of prejudice and interest, and when his propositions were decried because of their very originality, because they were new, strange, unheard of, and therefore contrary to verified opinion. What he wanted and could not find in his youth,

this Society presents to the youthful genius of this generation,—an enlightened, unprejudiced, and first ordeal, where every youthful inventor, every mechanic of original talent, every proposer of that which is new and promises to be useful, will find a body of experienced practical men, to whom the country looks up as her wisest men, ready and willing to listen to the plans, to test the proposals, to weigh the value, and to award the praise and approbation to which the rising Stephensons of this generation may aspire; but which the old Stephenson could nowhere find, and in the want of which he was compelled to expend many years of vigour and energy in obscurity and penury. Let us see that in our hands no youthful genius, however little known, shall find his genius obscured, or his energies discouraged, eclipsed, or extinguished. If I rightly interpret the feelings of this Society, they would hail with welcome any discovery, and co-operate heartily and disinterestedly in giving to the world its benefit, and to genius its honours and rewards.

Another circumstance must have greatly impaired the means of usefulness of Stephenson in his early life, and one that he most deeply felt: namely, the want of knowing that which other men were doing, and had done before him, in subjects allied to those in which he was occupying his mind. Thus much we know with certainty, that no man was more happy to communicate in after life to others the abundant stores of practical knowledge he had accumulated, and that no one felt a more kindly interest in the inventions and plans of younger men, or was more disposed to promote their interest and forward their views. Let us regard it as a part of his legacy so to impart, liberally, to all younger members of the profession, what more knowledge or greater experience may have enabled us to acquire. After all, there is no tribute more gratifying to the members of our profession than the due appreciation by each other of that which each of us may have done to advance the interests and increase the resources of mechanical science.

It would not be fair to the character of our late President to omit from our recollection the very large and original views which he entertained on general science. It has been too common in our profession to place science and practice in opposition to each other;

as if true science and hard practice could possibly be opposed. If science mean that which is carefully ascertained, and accurately defined, and truly demonstrated, then it is impossible that any sound practice can possibly stand in opposition to it or independent of it. If practice mean the knowledge which is founded on the actual facts and experience of intelligent men, it is impossible to see how the largest amount of that knowledge possessed by any one man can differ from the extensive and generalised facts in which science embodies the experience of all mankind. Stephenson is a remarkable instance of freedom from this prejudice. He was eminently a practical man. He wrought early, and much, with his own hands. He had wrestled with matter, and knew all its qualities by feeling it and pushing it and pulling it, by cutting and filing and chipping it. He had hammered it hot and hammered it cold, he had melted it and moulded it, planed it and sawn it, broken it across, pulled it asunder, and twisted it round. He knew its action and its reaction, its inertia and its momentum, its *vis mortua* and its *vis viva*. His was a supremely practical and personal acquaintance with the laws and property and phenomena natural to matter, whether solid or liquid, fluid or gaseous, mineral or aërial, more than that of any man who has ever risen to eminence. Stephenson was entitled to rank as a consummately practical man. But was he not equally, or more, a scientific than a practical engineer? Was there ever a bolder theorist than he was? Were there ever more daring scientific speculations than those wild flights in which his genius delighted to break forth? In chemistry, in vegetable physiology, in vital mechanism, in electricity, in galvanism, in the theories of the gases, on the inert constitution of matter, and of heat, and even on the mechanism of the mind itself, he had deeply thought, profoundly read, and boldly and fearlessly speculated. Every step in his life was the realisation of what had before been a theory. It is true he was not educated early in the rudiments of science, at school or at college; but what of that? What is life but a great school? Is not the press our school, and necessity our school of invention? Stephenson read and studied science; he was not ignorant, but he was self-taught. Before he became a great man he had studied

loes not appear to have ventured on any
ion, before having accurately, and generally
the principles of science its probable and
ll his works, Stephenson exhibits to us
ly practical, of the profoundest principles of
Let the men among us, who desire to emulate
to combine in the greatest degree the truest
est practical sense. These are not times in
afford to dispense with any science, or any
e in his power to obtain.

re upon an illustration of the advantage of
with extensive practice, which has often
n excellent illustration of Mr. Stephenson's
nd also as an illustration of the advantage he
s a practical man, from having been still more
an he was. Stephenson, we know, invented
d a great invention it was thought in its day.
Manchester Railway was opened with it. It
give, with a small addition of metal to the
he rail, nearly double the strength, and this it
hed. But here he stopped short: he had not
that by making the wrought iron bar in long
er a number of blocks or sleepers, he had
condition, to which a much higher rule was
ed the difference between a rail having a joint
ne having a joint only at every fifth or sixth
ed that, he would have invented the parallel
learned that the joint chairs require to be
those removed from the joint by a fixed
bellied rail was a failure. It was the result
ence of which there was not enough. It was
ice; but of practice under different conditions.
Mr. Buck, a profoundly scientific pupil of
op the true science of the wrought-iron rail.
science had failed, a little more made the
et us learn from this to be always trying to

obtain a little more science as well as a little more practice than we have got; remembering that Stephenson continued his education of himself to his dying day.

The best testimony however, which Stephenson has borne to the value of scientific education for a practical man, is to be found in the course he adopted for the training of his son to our profession. The assiduity with which he laboured at clock-making, the cleaning of watches, or any other industry, in the intervals of his regular business, in order that he might be able to afford to him those blessings of education of which he himself so deeply felt the want, is one of the most charming features in his character. His most earnest desire in early difficulty was to give Robert all those precious thoughts and truths which he himself acquired only late and too laboriously. And how admirably his plan succeeded, his son's unclouded successes, both as a Mechanical and a Civil Engineer, are the evidence to us, as indeed they were the subject of just pride to himself, who never spoke of his son without strong emotions of joy and pride. There are none of us who will question either the justice of his pride or the soundness of his plan of education.

It is one of the peculiarities of genius to inspire those within its influence with some of its own fire. This was peculiarly the case with Stephenson. Nearly all the present ornaments of our profession have been his pupils. He was the founder of a school of eminent engineers, who in England, Europe, and India, are now extending, amongst all portions of the human race, the blessings of those great bonds of civilisation and social intercourse which he first fabricated. It is to his labours and theirs that this country owes the addition of £200,000,000 to its productive wealth, the opening up of a host of new branches of industry, the quickening and invigorating influence of rapid and cheap intercourse; and to him that the poor everywhere owe the blessings of cheapened coal, and the facilities of social enjoyment and healthful recreation.

In this brief notice of the chief features and character of our late President, which I have thus imperfectly, although most earnestly,

sketched amid the bustle of business, I have dwelt mainly upon such features and characteristics as were peculiarly interesting or instructive to us, as members of an Institution founded, in a great measure by himself, for professional purposes. I have regarded therefore chiefly his professional character; but I cannot conclude without expressing an earnest wish that his life as a man, exhibiting the beauty and excellence of his character in all its cheering aspects, as a boy, as a workman, as an engineman, as a viewer, as an engine builder, as an improver of mineral railways, as the engineer of the Liverpool and Manchester Railway, should be written by some one who has leisure to collect from his many friends all their recollections of him, while they remain fresh and accessible. I should desire also to see a detailed account given of his progress, his difficulties, and his means of success in any one of his labours. This would be a most valuable and instructive work; and I do not know on whom it should devolve more properly to see such a work executed faithfully and judiciously than on this Society, whom he made the favoured recipients of his knowledge and experience, and who ought to consider themselves as his literary and scientific executors, to whom the world may naturally look to see justice done to the memory of one of England's greatest men, the founder of our railway system and of the Institution of Mechanical Engineers.

The memoir, which both at the close and during the time of reading elicited expressions of admiration, having been read, the Chairman said he presumed it would be unnecessary to put it to the vote, that the members return their best thanks to Mr. J. Scott Russell for his very able memoir. The vote was carried with acclamation.

Mr. Grace rose and said it was with melancholy satisfaction he begged to move, that they place on the minutes of their

proceedings an expression of the regret they all felt at the loss of so excellent a man as their late friend, Mr. George Stephenson, apart from his having been the President of this Institution. He well recollected Mr. Stephenson, on the last occasion of their meeting, filling the place which Mr. McConnell now so worthily occupied, in high spirits and in good health. The recollection of the circumstance cast a gloom over his feelings, and he was sure it would have the same effect on every member present. He had known Mr. Stephenson a shorter time perhaps than many of them; but he had known him well enough to entertain not only respect for him but affection also. There was something so endearing about his manners, so open and kind, and so encouraging to all those less experienced than himself, there was so much of kindheartedness about him, that no one could help entertaining for him a high respect. He would quite allow that his manners were sometimes rough; he would quite allow that there were peculiarities in his character, which had to be considered as peculiarities: but he was quite sure those who knew him best considered that these very peculiarities gave him a greater claim on their regard. He was willing to allow that he had seen in Mr. Stephenson what in other men might subject them to criticism; but when it came from Mr. Stephenson, it came from a privileged person. Mr. Stephenson was proud of his own early life, and he never lost any opportunity of expressing it; he never attempted to conceal that he came from the lowest grade of society, and had raised himself to his high station; and he ever evinced the same pleasure in meeting an associate of his early life, in humble circumstances, as he did in meeting the peers of the realm, with many of whom he associated in later life. He had the same gratification on meeting one whom he had known in early life, or the son or connection of such a one, and in referring back to the time when they had struggled together through difficulties, as he had in referring to the occasion when he was taken by the hand by the highest in the land. Although oppressed with these recollections, he could not content himself without making the few remarks he had made; and he now begged to move,—"That the members of this Institution desire to express

he decease of their late President, George
rly support of the Institution so greatly
o its present state of prosperity and success."
seconding the resolution, expressed his great
uty should devolve upon him. After the
ach he should content himself with merely
n, for he was sure that every one participated
f deep regret. The resolution was put and

rose and said that, immediately on hearing
e President, the Council met at Manchester,
letter of condolence to his widow for the
ad sustained, they resolved that the best
to the late Mr. Stephenson's memory, and
they could testify their appreciation of his
same time the best selection of a future
ake from among the eminent men of the day,
Robert Stephenson to become his father's
of this Institution. The Council did so,
members would entertain the same opinion.
Council were appointed a deputation to wait
Owing to an accident they were prevented
nson; but a most satisfactory and pleasing
l, which would be read by one of the
ds it would be his duty to nominate Mr.
he future President.
id that Mr. Buckle and himself were the
wait on Mr. Stephenson; but for the reason
n they had not been able to see him. They
pondence, and Mr. Stephenson's reply did
aracter as a man and to his feelings as a
ot the letter with him; but the substance of
, nothing would be wanting on his part to
f the office in a manner satisfactory to the
would endeavour to watch over the interests
rnestly as his lamented father had done.

The CHAIRMAN then begged to propose Robert Stephenson, Esq., as President of the Institution. He felt certain that every member would agree with him, that a better choice could not be made. Mr. Robert Stephenson was a worthy son of a worthy father; and the Institution would gain additional lustre by having that gentleman as its President. The resolution was seconded by Mr. Fothergill, and carried unanimously, amid every demonstration of satisfaction.

Mr. KINTREA, the Secretary, then read the following Paper, by Mr. John Jones, of Bristol:—

ON THE ADAPTATION OF THE "CAMBRIAN" ENGINE TO LOCOMOTIVE PURPOSES.

The following is a brief description of the advantages to be derived by the application of my "Cambrian" engine to locomotive purposes. One has already been made by Messrs. Thwaites and Co., Engineers, of Bradford, named the "Albion," which I understand gives every satisfaction.

On referring to the drawings which accompany this paper, it will be seen that the side elevation, No. 5, shows the side levers as connected to the wheels. The levers are fitted on to the ends of the piston shafts, which work in separate bearings; from the opposite ends of these levers pass connecting rods to the crank pins on the leading and centre driving wheels; on each side of the engine, the pistons communicate an oscillating motion to the double levers, the length of which is so adjusted as to cause the driving wheels to make whole revolutions; by this arrangement the strain of the working parts is balanced: there is no centre pressure, and all dangerous oscillation is completely avoided.

Another advantage derived from the mode of connexion is the oscillating lever ends passing through a great part of a circle, gaining power, as it does, at the extremities of the stroke, to compensate for the loss of power in the cranks, as they approach the dead centres. The circle that the crank pin centre moves through is divided into twenty parts. It may be seen by the diagram that, as the lever approaches the extremities of its stroke, the actual length diminishes and becomes from 18 inches to $17\frac{3}{4}$, 16, $15\frac{1}{4}$, 14, and $13\frac{1}{4}$ inches at the centres, so that the power of the lever increases in proportion to its diminution in length; which compensates in a great measure for the loss of power in the crank, as it approaches the dead centres.

I presume the principle of the "Cambrian" engine is tolerably well known, as it has now been before the public upwards of seven years; several having been at work for more than six years, to the entire satisfaction of the persons using them. I therefore feel satisfied as to its superiority over the common cylinder engine, as the wear and tear is much less, in consequence of there being fewer working parts.

I have now pointed out what I consider to be the advantages of this engine, namely:—obtaining a long stroke in the crank, without the disadvantages of a long-stroke cylinder, where high velocities are required: the arrangement of the levers which balance the engine: the entire disappearance of any oscillating motion of the engine: doing away with all centre pressure, an object of the highest importance, and one that deserves more attention than it has hitherto received.

In the absence of Mr. Jones and at the request of the Chairman, Mr. E. A. Cowper, with the assistance of diagrams, further explained the construction of the engine, commonly known as the "Cambrian" engine; but added that as applied to locomotion he had never seen it until that morning. In answer to numerous questions Mr. Cowper stated, that although he did not altogether recommend the "Cambrian," he had often known it to work

satisfactorily. As compared with ordinary engines he could not see any great advantage in it.

In answer to a question, Mr. SLATE stated that he had had some experience with rotary engines, which the "Cambrian" engine somewhat resembled, and the conclusion he had come to was by no means favourable to that principle. At the same time he did not see any difficulty with Mr. Jones's plan; and as far as he could perceive, the difference between it and the ordinary engines consisted in the fact, that the "Cambrian" had the advantage of having the principal weight between the wheels, whereas by the ordinary arrangement the weight was in front of the driving wheel. In other respects the "Cambrian" very much resembled the locomotive lately made by Mr. Wilson of Leeds; the principal difference being that in the latter there was a strain on the bearing of the centre shaft, which he did not find in the former; otherwise the action of the balancing of the engine was exactly the same.

Mr. CRAMPTON said there were two bearings of the shaft to which Mr. Slate referred. He had paid some attention to this matter, and he thought that the intention was to balance the engine or locomotive with the momentum of the parts, so as to avoid oscillation. He would show a practical objection which he conceived to exist: suppose three shafts in a right line, with a lever for the centre shaft, and a crank on either side; when in a perfectly straight line, the lengths remained the same; and if on a table, or on any perfectly smooth surface, it worked as sweetly as possible. On a railway however, supposing there to be three wheels, and the road to be a little out of order, the one shaft would be thrown out of the line referred to, and as the spring deflected $\frac{3}{4}$ inch, it would have the tendency to lengthen the connecting rod, which could not revolve past the centres without straining the parts, but which, with the ordinary connecting rod, would produce no bad effect.

The CHAIRMAN said that there certainly seemed to be an objection; in fact the line of the three centres would be destroyed.

Mr. CRAMPTON:—The thing works perfectly when the parts are in one line; but as soon as they get out of the line, there is an undue strain.

ock, Mr. CRAMPTON admitted that additional
n to the axles of the wheels, with cross bars
d bearings of the centre shaft; but it would
xtra ton or two in weight, which could not

e case of Wilson's engine, where there were
cross bars, the objection would not be so

vould be greater in the "Cambrian" engine
use in the former there is a cylinder to

see that a little extra weight between the
ould be of material effect, it being supported
ported 5 cwts. it could support 15. Perhaps
our the meeting with his opinion of the

t had sufficient experience; but as far as he
work beautifully. As to the outside levers,
aint of inconvenience; in fact it must be
hat would cause the shaft to deviate an
, and then it would be but for a moment.
shaft was supported from the frame of
e whole weight of the engine was on the
gine the three shafts, or centres, to be in a
ation from it would be but for a moment, as
egain its position, unless the springs were
perience of Wilson's engine, he had no
being outside; but how long these might
ng.

ever seen any engine work so beautifully and
motive. His objections were principally of
maintained that that engine could not be
h of time. It was inherent in it to increase
of the connecting rods by $\frac{1}{8}$ inch. In the
ilway, the engines could not always pass
of the superintendent; and hence durability

was a matter of great importance. At the same time he must tell them what he had seen; and on an even surface he had never seen a steadier working engine. All the weight was between the two rods, which he considered to be the great reason why the oscillation was avoided.

Mr. SLATE gave it as his opinion that, with reference to the question of the form of the cylinder, he could not see that the form of the vessel was of any particular consequence, so that the space were filled with steam. The power derived would be just equal to the quantity of steam contained in the cylinder. In that view he saw nothing to object to in the circular form of the "Cambrian" cylinder; and otherwise the engine under consideration had good points. The outside levers and the two cranks worked admirably; and the only question was whether it would support a cylinder of the weight required between the two shafts. He saw no objection to the application of the "Cambrian" to locomotive purposes; but he did not feel quite competent to give a positive opinion.

Mr. COWPER said that Mr. Crosley, a person interested in the engine, had told him that it had been tried on the line between Birmingham and Derby, and that it not only burnt 5 lbs. of fuel per mile less, but took a heavier load than any other engine.

Mr. HUMPHRYS was rather inclined to think that it would go forth that the principle of the invention had met with the approbation of the meeting; but as far as he had been able to discover, he could not see any reason why steam applied in this particular way should do better than in the ordinary way of a simple cylinder. As Mr. Cowper had had considerable practice in steam engines, he wished to know if, in making a steam engine, he would be disposed to adopt Mr. Jones's plan.

Mr. COWPER begged to guard himself against the supposition that he saw any advantage in the plan, or in the form of the cylinder.

Mr. HUMPHRYS could only record his own opinion, that no possible advantage could be obtained by so applying the steam; but on the contrary a disadvantage; for they had to get over the difficulty of connecting all the joints.

Mr. Cowper said the cylinder was perfectly tight.

Mr. Slate did not consider that, in the absence of Mr. Jones, they were in possession of sufficient information to enable them to arrive at a decision on the merits of the plan. At present they had no particulars as to the size of the engine, the pressure of the steam, the size of the connecting gear, and various other matters.

Mr. P. R. Jackson expressed it as his opinion, that the rotary engine was a far better application to locomotion than the "Cambrian" engine. He well recollected a gentleman calling at his foundry in Manchester some years ago, and in compliance with that gentleman's request he cast for him the parts of a rotary engine; at the same time expressing his opinion that it would do no good. The engine however was completed; it cost the inventor £400, and in two years afterwards it came back to him for £14.

Mr. Cowper remarked that the objections of Mr. Crampton extended to the coupling of any engine; for as one wheel went up and the other down, the connecting rod must vary. It did not hold to the same extent in all cases; but still it did hold.

Mr. Slate enquired whether the objection might not be overcome by making the guard plates a little larger.

Mr. Crampton replied that this was being done; but he conceived there was a still greater objection to that alteration.

The Chairman thought they had not sufficient data before them as to the economy of the engine, or even as to its adaptation to the purpose designed, to enable the meeting to form a correct opinion. He therefore presumed that at present it would be premature to come to a conclusion as to its merits.

Mr. Beyer gave it as his decided opinion that the ordinary straight cylinder would work better than the curved one of the "Cambrian."

The Chairman then requested Mr. Fothergill to read the following Paper, by Mr. William L. Kinmond, of Dundee:—

DESCRIPTION OF A RAILWAY CARRIAGE ELEVATOR.

The Glasgow terminus of the Glasgow and Ayr Railway is 20 feet above the level of the street, and the Elevator was constructed in 1840 for raising and lowering the goods trucks to and from the level of the goods warehouses and the street.

A, as marked on the drawing, is a travelling platform of sufficient length and breadth to receive one goods truck; on the upper side are two rails, which coincide with the rails in the station. When the platform is at the top or bottom, it forms a hatch in the floor of the station, upon which the truck to be lowered or raised is placed.

The machine is supported at the corners by four large cast iron columns, joined together at the top by cast iron beams, which are strengthened by ornamental brackets, presenting the form of an arch on all the four sides; the whole resting on a substantial foundation of masonry. The driving machinery is all placed below the level of the warehouses, or immediately beneath the platform when at the lowest point.

B is the main driving shaft, communicating motion through the friction wheel to the mitre wheels D E, and by a reversing clutch to the shaft G. When the platform has to be raised, the clutch is geared with the wheel D, and when it has to be lowered, the clutch is geared with the wheel E: the intermediate shaft K transmits to the shaft I a motion corresponding with that of the shaft G. Four pairs of mitre wheels, at the extreme ends of the shafts G and K give motion to four upright shafts, reaching from top to bottom of the elevator. On these shafts are four screws, made to revolve with the shafts, and at the same time to slide freely up and down on them by means of a groove in the shaft and a feather or fixed key in eye of screw.

Four plummer blocks are bolted to the sides of the platform, and are its resting points upon the screws. These plummer blocks also serve to steady the screws and upright shafts at their points of action. A bracket bolted to the platform secures the screws in their places. The screws act into four circular racks, extending from top to bottom of the machine, and constructed to turn freely on their axes along with the screws, the peripheries of both going at the same velocity, thereby saving a great amount of friction. The racks are steadied by two intermediate bearings, which do not at all interfere with the working. From this arrangement it will be observed, that when the screws are turned one way the platform rises, and when turned the contrary way it is lowered.

Supposing the platform to be at the bottom, it is put in motion upwards by means of a handle in the socket P. The rocking shaft G, by means of the spanners and connecting rod O N, moves another rocking shaft R. On the other end of the rocking shaft R is a lever, which throws the clutch into gear with the wheel D; thus giving the proper motion to the screws for raising the platform.

It will be noticed that the same movement which turned the rocking shaft R, moved backward the rod T, bringing the point Q of the rod within range of the eccentric V, which slides on a key on the intermediate shaft. In its present position it would revolve without touching the point Q of the rod T; but when the platform reaches the top, it touches a catch on the upright rod W, moves the rod X forward, and the pin attached to the rod sliding in the angled slot Y causes the end of the rod to move laterally, and the rod being connected with the eccentric brings it into contact with the point Q of the rod T, sweeping it back in its former position, and the machine is again out of gear and at rest.

This machine can be stopped at any point of its ascent or descent. There is a friction break to be used, should the platform gather too much way in descending, or to hold on with in case of anything giving way. The weight of the platform is balanced by weights, suspended by means of chains over pulleys inside the main columns.

The elevator is driven by a 6 horse engine, and lifts from 8 to 9 tons; the time taken to rise from the bottom to the top is about one

minute. It has been in constant use ever since its erection, and has given great satisfaction, the screws and racks having been only once renewed.

At the request of the Chairman, Mr. Slate, who had traced the references to the diagram during the reading of the paper, said that in the view he took this elevator appeared to embrace everything that was necessary for safety and efficiency. The front elevation of the driving gear was such as he had ordinarily seen in the old kind of planing machines; and the contrivance with a view of stopping it from descending was a very ingenious application of different forms of levers and connecting rods. The action seemed to him to be perfect, and it was impossible that it should not be under the complete control of the breaksman.

Mr. Fothergill said it appeared to him that the principal feature was the character of the revolving rack. The thread of the worm of the screw kept pace with the revolving rack, and thereby prevented any great friction.

Mr. Hoby thought Mr. Fothergill had pointed out the best feature in the elevator. The question was, which was the best kind of hoist. He saw it when it was first put up, and it worked remarkably well. The one on the Manchester and Leeds Railway was worked by flat ropes.

Mr. Crampton had also seen it at work; but did not take particular notice beyond that it worked well.

The Chairman presumed that he might take it as their opinion, that it was a very good application of the revolving rack. He saw it within six months of its erection, and was very much pleased with it. He had recently been told by Mr. Robertson, the locomotive superintendent of the line, that it worked very well indeed, never having required repairing except in one instance, and that some time ago.

A vote of thanks to Mr. Kinmond was then passed, for his interesting paper, the Chairman adding that it was very desirable to encourage these communications from distant members.

Mr. Cowper then read the following extract from Mr. Wicksteed's printed report on Brockedon's application of vulcanised india-rubber to pipe joints:—

VULCANISED INDIA-RUBBER PIPE JOINTS.

On the 22nd of May experiments were tried upon the new rings and filletted pipes:—

Exp. 5th. 4 inch joint, spigot *without* the upper fillet, stood 658 feet pressure, and gave way under 733 feet.

Exp. 6th. 4 inch, spigot *with* the upper fillet, stood 1241 feet pressure, and was not tried further.

Exp. 7th. 9 inch, spigot *without* the upper fillet, stood 733 feet, but worked and leaked very slightly from 240 feet pressure upwards.

Exp. 8th. 9 inch, spigot *without* the upper fillet, stood 755 feet, leaked as before, and blew out at 945 feet pressure, *after* four or five strokes of the pump.

Exp. 9th. 9 inch, spigot *with* upper fillet, stood 1241 feet; at 945 feet it worked and leaked very slightly, and continued to do so at 1241 feet, but it did not blow out, the belt preventing it.

Exp. 10th. 12 inch, spigot *without* the upper fillet, stood 733 feet, and at 900 feet, after working the pump for some time, it gave way.

Exp. 11th. 12 inch, spigot *with* upper fillet, stood 600 feet. The ring was so thick that it could not be made to enter the joint properly, and when joined the ring oozed out past the belt, so that no fair trial could be made.

Exp. 12th. 12 inch, spigot *with* upper fillet, stood 1333 feet. The ring was again too large, and if it had not been kept in by the belt would not have stood the pressure; the ring oozed out all round the joint, but stood the pressure without leakage. After a few strokes of the pump however the iron pipe burst. The pipe was 9-16ths inch thick, but there was an air-bubble flaw in it.

After a variety of experiments tried in the months of Apri May, July, and August, some in the presence of Mr. Brockedon an Professor Cowper, the proper thickness of rings and forms of socket and spigots were determined on, and the following very satisfactor results were arrived at :—

Exp. 13th. The 12 inch stood a pressure of 600 feet, and at first 90 feet, but after working the pump for a short time it gave way.

Exp. 14th. The 4 inch stood a pressure of 1333 feet without givin way at all.

This result showed that the rings of the 12 inch were too light and that the 4 inch, although it stood the greatest pressure, appeare to enter the socket too easily; I therefore proposed to increase thei weight to $4\frac{1}{2}$ oz. and $1\frac{1}{2}$ oz. respectively.

Upon July 31st, 1848, the new rings were tried, the 12 inch weighing $4\frac{2}{3}$ oz., the 4 inch $1\frac{1}{2}$ oz. :—

Exp. 15th. The 12 inch stood a pressure of 900 feet; but after severa strokes of the pump at a pressure of 1333 feet, it blew out at a defect in the upper fillet on the casting.

Exp. 16th. The 4 inch stood a pressure of 1333 feet without giving wa at all.

Exp. 17th. The 12 inch stood a pressure of 1333 feet.

Upon the 15th of May the five 4 inch pipes were joined together without fillets on the pipes, and with the imperfect rings supplied at that time as before described. These joints have been exposed to a varying pressure of from 90 to 175 feet up to August 21st, being a period of above three months, and they are now perfectly tight, and no change has taken place.

The time occupied in these trials has been above five months, and I am now enabled to speak very confidently of the value of the new joints. It appears that for a 4 inch joint, the space between the spigot and socket being $\frac{1}{4}$ inch all round, the vulcanised india-rubber ring should weigh $1\frac{1}{2}$ oz.; and for a 12 inch ring, the space between the spigot and socket being the same, namely $\frac{1}{4}$ inch, the weight of the ring should be $5\frac{1}{4}$ oz.

The spigot and socket ends of pipes to suit the vulcanised india-rubber rings should be formed as follows:—the depth of the socket for all pipes up to 12 inch, which is the largest I have experimented

½ inches; the thickness of the joint or space
e of the spigot and inside of the socket should be
l be no occasion for extra strength in the sockets,
osed to any blows or to the force of the wedge in
s in lead or wood joints. The spigot should have
ead or belt, 3-16ths inch thick and ½ inch deep,
en a clear space of 2½ inches, and another belt of
ns.

ted the weight and cost of 100 rings of various
e the number required for 300 yards of pipes, as
eing 5*s*. per lb.:—

pe.	Weight per 100 Rings.		Cost per 100 Rings.		
	Lbs.	oz.	£	s.	d.
	7	0	1	15	0
	9	6	2	6	11
	12	5	3	1	7
	15	4	3	16	3
	18	3	4	10	11
	21	2	5	5	8
	24	1	6	0	4
	27	0	6	15	0
	29	15	7	9	8
	32	14	8	4	5

comparison between the cost of the vulcanised
ts and lead or wood joints, I have in the following
ed only the material, the labour in making the joint,
on and filling in of the trench, but including 10 per

	Lead Joints.		Wood Joints.		India-rubber Joints.	
	s.	d.	s.	d.	s.	d.
yard run	0	6·6	0	4·6	0	3·3
yard run	1	7	0	11	0	9·9
9, 10, 11, l of each, total.....	10	0	6	2	5	2

yard of each of the ten sizes of pipe from 3 inches to
ive, and, in addition to the above, adding the average
the pipes to the trench, removing surplus earth,
s, lead pipes, &c., and all other charges and risks,

and guarantee for twelve months, *excepting* the charges of the commissioners of roads or streets for paving, &c., the cost of the 10 yards will be as follows:—

Lead Joints.	Wood Joints.	India-rubber Joints.	India-rubber Joints cheaper than Lead.	India-rubber Joints cheaper than Wood.
s. *d.*	*s.* *d.*	*s.* *d.*		
23 10	20 6	19 6	22 per cent.	5 per cent.

Mr. Cowper exhibited and explained a diagram, showing the nature and operation of the joints; and having stated that the cost would not exceed one half of that of the ordinary lead joints, a member enquired what would be the comparative durability. He was given to understand that lead would endure for 50 years.

Mr. Fothergill apprehended great difficulty in repairing the joints, without disturbing a great number of adjacent pipes.

Mr. Clift had no doubt they would answer extremely well for street mains, or in straight lines; but doubted with Mr. Fothergill, whether in the event of an escape of gas or water they could be conveniently repaired in angular positions. He conceived that the greater the pressure of water the sounder would the joint be; but the less the pressure the greater the liability to escape.

Mr. Richards spoke to an experience of twelve months of the joints in question. In the month of June he had occasion to re-lay the town of Worcester with new gas mains, the vibration of the road having induced leakage to a considerable extent. He accordingly applied to Messrs. Macintosh for some of these joints, and could speak in confident terms to the value of the invention. He first applied them in the works, to ascertain whether they would sustain the effect of the ammonia and corroding gas, and he had also tried them in the street; and in both cases they were entirely unaffected by the components of the gas, and still remained perfectly tight. He had also applied them in the street mains, and they were

the old joints. With reference to the expense, of the old plans, and there was by no means airing them which seemed by some to be had recently tested it where there was an ees, and by removing half a dozen joints he the repair desired, which could not have been he old ones. In fact he believed them to be else in use, and intended to apply them to y.

d it appeared to him to be a very valuable they left off the bead in the pipes, which fectly useless, they might incline or angle the

greed with the last speaker, that on the plan ncline the pipes to any extent; and the only against was the fact that it would require a rtain their durability. They could not tell how of temperature would influence them; but could see, the invention was a very valuable

rved that he had had some of the pipes exposed ature throughout the whole of last winter; and rost he found they still retained their form and npervious to the action of all gaseous matter.
n remarked that he presumed, from what had ject, that it was the sense of the members that l application, and that on all points, excepting ich time alone could determine, it had their rks of the Chairman met with the affirmative bers.

The CHAIRMAN intimated that the further consideration of Mr. De Bergue's Collision Apparatus and of Mr. Richmond's Engine Counter must in the absence of those gentlemen be postponed.

The CHAIRMAN announced that the Committee of Council appointed to revise and alter the Rules, as authorised by the Annual Meeting in January last, had finished their labours; and a copy of the proposed alterations he held in his hands. The Council had determined that before asking the sanction of the members to these new Rules each member should be supplied with a copy; so that between the present time and the next meeting they should all be able to form an opinion on them. At the next meeting they would be put to the vote. The existing rules required that the proposed Council and Officers for 1849 should be put in nomination at the present meeting; the Council were accordingly prepared with a list of gentlemen whom they begged to nominate, leaving it to any member of the Institution to add to the number. The following is the list:—

PRESIDENT.

ROBERT STEPHENSON, Esq.

VICE-PRESIDENTS.

JOSEPH MILLER,	JOHN PENN,
J. E. MCCONNELL,	DAVID ELDER,
CHARLES BEYER,	JOSEPH WHITWORTH.

COUNCIL.

EDWARD HUMPHRYS,	W. A. MATTHEWS,
J. SCOTT RUSSELL,	ROBERT SINCLAIR,
BENJAMIN FOTHERGILL,	ARCHIBALD SLATE,
R. B. PRESTON,	WILLIAM WEALLENS,
WILLIAM BUCKLE,	RICHARD PEACOCK,
E. A. COWPER,	JOHN RAMSBOTTOM,
JAMES FENTON,	WILLIAM HARTREE,
THOMAS CABRY,	P. R. JACKSON.
EDWARD JONES,	

TREASURER.

CHARLES GEACH, Esq.

No names having been added, the list was adopted by the meeting.

continued—Another matter for the consideration
is to receive the announcement of the Council that
etary, Mr. Kintrea, had tendered his resignation.
l therefore made enquiries, and had agreed to
leman whom they considered well qualified to
rea, namely, Mr. W. P. Marshall, lately Locomotive
Norfolk Railway. Mr. Kintrea would at the close
ipply the members with copies of the lithographs
rawings of the Luggage Engine "Atlas."

conversation ensued as to the high qualifications of
minated as Secretary, and also with reference to the
the rule affecting the election of officers.

JSE then rose and said it gave him great pleasure
rty vote of thanks to Mr. Kintrea, the Secretary,
cient and satisfactory manner in which he had
ities of his office, and for his great attention to the
Institution.

N entirely concurred in the proposed vote; and
ouncil had already passed a resolution, and entered
s, expressive of their high sense of Mr. Kintrea's

n was seconded by Mr. BUCKLE, as a member of
ed with acclamation.

briefly returned thanks; and the proceedings

INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

HELD IN BIRMINGHAM, ON 24TH JANUARY, 1849.

J. E. M'CONNELL, ESQ., V.P.,

IN THE CHAIR.

BIRMINGHAM:
BENJAMIN HUNT AND SONS, 75, HIGH STREET.

1849.

PROCEEDINGS.

The Annual General Meeting of the Members was held at the Queen's Hotel, Railway Station, Birmingham, on Wednesday, the 24th of January, 1849; J. E. M'Connell, Esq., V.P., in the Chair.

The minutes of the last General Meeting having been read by the Secretary, were confirmed.

The Chairman rose and said, they were meeting to record their proceedings at the Second Annual Meeting of the Institution of Mechanical Engineers; and it had fallen to his lot to occupy the office of Chairman, in consequence of the absence on the continent of their President elect, Mr. Robert Stephenson, whose absence they very much regretted. In accordance with the rules, the Council had drawn up a report of the proceedings of the last year, which he would proceed to read.

INSTITUTION OF MECHANICAL ENGINEERS.

SECOND ANNUAL GENERAL MEETING, HELD 24th JANUARY, 1849.

REPORT OF THE COUNCIL.

The Council have great pleasure and satisfaction at this Second Annual Meeting of the Institution, in congratulating the members on the continued and successful progress of the Institution, and the large increase in the number of the members; who have been nearly doubled during the last year, and amount to 189 Members, of whom sixteen are Honorary Members.

This increase in the number of members has been greater than was expected to take place in the time, and shows that the advantage and importance of this Institution are felt and appreciated by the Engineering and Mechanical Profession; it promises

well for the future progress and extension of the Institution, and its efficiency in carrying out the objects for which it was originally founded.

The Council wish to draw the attention of the members to the importance of giving all the assistance in their power to advance these objects and increase the utility of the Institution by obtaining the addition of new members, and particularly by the communication of papers, with drawings and models, descriptive of new inventions or improvements that have been made by them, or have come under their observation, and the particulars of experiments and trials made with new or old machinery, etc. or the register of the regular working of stationary engines, locomotives, or other machines.

The Council invite communications from all the members and their friends on any engineering subjects that will be useful and interesting to the Institution; and they hope that no members will withhold their communications on account of the want of opportunity to make them so complete and lengthened as they desire; as it is one of the first objects of the Institution to collect and record facts relating to the professional experience of the members, and to procure early and authentic information respecting new mechanical inventions and improvements, for the mutual information and advantage of the members.

Amongst the communications from the members during the last year, the Council have the pleasure of acknowledging in particular the following additions to the Papers of the Institution :—

On A Perforating Machine	*by Mr. Fothergill.*
— Balancing of Wheels in Locomotives.........	*Mr. M'Connell.*
— Rotary Engines	*The President.*
— Boring Cylinders	*Mr. Beyer.*
— Boiler Explosions	*Mr. Smith.*
— A new Boiler and Condenser	*Mr. Craddock.*
— An Hydraulic Starting Apparatus............	*Mr. Jackson.*
— An Express Locomotive Engine	*Mr. Samuel.*
— A Railway Carriage Elevator..................	*Mr. Kinmond.*
— A Machine for preparing Bone Manure ...	*Mr. Buckle.*
— The Cambrian Engine	*Mr. Jones.*
A Memoir of the late President.................	*Mr. Scott Russell.*

The Council have to allude, with feelings of the deepest regret, to the recent loss sustained by the Institution in the death of their late President, who will be always remembered by the members with the greatest respect and esteem, not only as a man of exalted genius, but as the first President, and the early and efficient supporter of this Institution.

A careful revision of the Rules and Bye-Laws of the Institution has been made by a Committee appointed for the purpose, in accordance with a resolution of the members; and a revised set of Rules, prepared by this Committee, has been circulated amongst the members, and is submitted to them for approval at the present Annual Meeting.

The Officers of the Institution go out of office this day according to the rules, and a ballot will be taken at the present meeting for the election of the Officers for the ensuing year. In submitting the list of Officers nominated at the last meeting of the Institution, to be elected at the present meeting, the Council congratulate the members on the willingness of Mr. Robert Stephenson to succeed his late lamented father as the President of this Institution. They also consider it fortunate that they have been able to prevail upon Mr. Marshall to accept the office of Secretary, vacant by the resignation of Mr. Kintrea; if it shall be the pleasure of this meeting to appoint him to that office, the duties of which he has been performing pro tem.

The following Report has been made by the Finance Committee, containing the Financial Statement of the affairs of the Institution for the year ending 31st December, 1848.

REPORT OF THE FINANCE COMMITTEE,

To the Council of the Institution of Mechanical Engineers, Jan. 19, 1849.

Your Committee having carefully examined and checked the various receipts and payments of the Institution during the year ending the 31st December, 1848, beg to report that the enclosed Balance Sheet rendered by the Treasurer is correct.

Since the 31st December, the account has been paid for the engravings of the Atlas Luggage Engine and the Multifarious

Perforating Machine, that have been supplied to the members; leaving an available balance now in hand of £147. 9*s*. 1*d*. There are several copies of these engravings remaining in the possession of the Institution, which are intended to be supplied to the members at a moderate price, and for the purpose of affording an opportunity to the future members, and members' friends, of obtaining copies of these very excellent and valuable engravings.

(Signed) ARCHIBALD SLATE.
E. A. COWPER.
WM. BUCKLE.

INSTITUTION OF MECHANICAL ENGINEERS.

BALANCE SHEET,

For the Year ending 31*st December*, 1848.

Dr.	£.	*s.*	*d.*	*Cr.*	£.	s.	*d.*
To Subscriptions from 3 old Members, being arrears for 1847	15	0	0	By Advertising, Stationery, and Printing	87	18	7
— Subscriptions from 52 old Members for the year 1848	156	0	0	— Petty Disbursements and Office Expenses	23	7	2
				— Office Furniture	22	16	6
				— Postages	27	8	9
— Subscriptions from 110 new Members for the year 1848	550	0	0	— Travelling Expenses	23	11	4
				— Rent of Office	45	0	0
				— Salaries	300	0	0
— Donation from J. MacGregor, Esq.	20	0	0	— Subscription paid in excess	5	0	0
— Balance from 31st Dec., 1847	218	6	5	— Balance	424	4	1
	£959	6	5		£959	6	5

(Signed) ARCHIBALD SLATE.
E. A. COWPER.
WM. BUCKLE.

19*th January*, 1849.

The CHAIRMAN observed, that the Council, in retiring from office, all agreed that the advantages had not yet been fully reaped which an Institution of this description was calculated to bestow on its members. The last year had been a particularly unfortunate one as respects the officers of the Institution; they had lost their late respected President, and there had necessarily been some want of active management caused by the change of officers, which,

together with the depression of the times, had rendered the efficiency of the Institution less perceptible than it would otherwise have been. They now, however, saw the elements of success strongly marked; and, as the report recommended, it rested with the Members themselves to carry out the objects of the Institution, and to make it, as it deserved and was intended to be, the first institution for the class of subjects for which it was founded. He regretted very much that they had not had at that meeting the presence of their President elect, Mr. Robert Stephenson, a gentleman whom they all respected, and who, he was sure, would do all in his power to extend the benefits of this Institution and promote its best interests. He hoped that at their next quarterly meeting they should have the pleasure of meeting Mr. Robert Stephenson, who would then be able to impress on them, with more power than he was capable of, the advantages which this Institution will afford to the members, and which he had no doubt will be obtained by proper attention to the object for which it was founded, (applause).

Mr. RAMSBOTTOM said, he had great pleasure in moving the adoption of the Report that had just been read.

Mr. WHITWORTH seconded the motion, and it was passed.

The CHAIRMAN said, the next subject for their consideration was the appointment of the President for the year ensuing. Mr. Robert Stephenson was proposed at the last meeting; but in order to comply with the rules of the Institution, it was necessary that he should be formally elected by the members at the Annual Meeting. He felt sure it was quite unnecessary for him to say one word in support of that proposition, as Mr. Robert Stephenson was a gentlemen so well known, and his character and talents were so universally acknowledged; he therefore begged leave to propose him as President of the Institution of Mechanical Engineers.

Mr. FOTHERGILL said, he had very great pleasure in seconding that nomination, and the resolution was passed with acclamation.

The CHAIRMAN said, the other appointments of Treasurer and Secretary were now to be filled up for the ensuing year.

Mr. THORNTON (Mayor of Birmingham) said, he rose with

great pleasure to propose a vote of thanks to the respected Treasurer of their Institution for the past year, Mr. Charles Geach, and he begged to propose that he be elected Treasurer for the ensuing year. He very much regretted that indisposition prevented Mr. Geach from being amongst them on the present occasion; the more especially as he was prevented by a similar cause from being present at the last Annual Meeting. Since then he had been amongst them, but to the extraordinary manner in which he had performed the duties of his recent office of Mayor might be attributed, in some measure, his present indisposition. They would recollect the great interest which he took and the attention he bestowed in the formation of this very valuable Institution; and the interest he takes in attending the meetings must render it a source of great regret to the members that he was not able to be present at that meeting.

The resolution was seconded by Mr. Buckle, and carried.

Mr. Henderson proposed that Mr. Marshall be appointed Secretary for the ensuing year; he said the members so well understood the qualifications of Mr. Marshall for that office, that in his presence he thought it quite unnecessary to make any remarks on the subject; he most cordially proposed his appointment.

Mr. Peacock said he had great pleasure in seconding the appointment of Mr. Marshall to that office, and the resolution was passed.

The Chairman said the next subject to be considered was the Rules. The members would recollect, that at the last annual meeting, a Committee was appointed for the purpose of making certain amendments considered necessary in the rules. That Committee had drawn up an amended code of rules, of which a copy had been sent to all the members for their consideration, and it was the duty of that meeting to decide upon these rules. He moved that these rules, as submitted to the members, be now adopted as the Rules of the Institution.

Mr. Slate seconded the motion, and said, that as one of the Committee engaged in re-modelling these rules, he felt that their best attention had been given to them; and the resolution was passed.

The Chairman said, the Committee appointed to open the ballot lists, reported that the following members were elected as the Vice-Presidents and Council for the ensuing year.

VICE-PRESIDENTS.

Mr. CHARLES BEYER, Manchester,
Mr. J. E. M'CONNELL, Wolverton,
Mr. JOSEPH MILLER, London.

COUNCIL.

Mr. WILLIAM BUCKLE, Birmingham,
Mr. THOMAS CABRY, York,
Mr. E. A. COWPER, Birmingham,
Mr. JAMES FENTON, Leeds,
Mr. BENJAMIN FOTHERGILL, Manchester,
Mr. EDWARD HUMPHREYS, London,
Mr. EDWARD JONES, Bridgewater,
Mr. W. A. MATTHEWS, Sheffield,
Mr. RICHARD PEACOCK, Manchester,
Mr. R. B. PRESTON, Liverpool,
Mr. JOHN RAMSBOTTOM, Manchester,
Mr. J. SCOTT RUSSELL, London,
Mr. ROBERT SINCLAIR, Glasgow,
Mr. ARCHIBALD SLATE, Dudley,
Mr. WILLIAM WEALLENS, Newcastle-on-Tyne.

The Chairman announced that the following new Members were also elected.

MEMBERS.

Mr. CHARLES COWPER, London,
Mr. WILLIAM FAIRBAIRN, Jun., Manchester,
Mr. JOHN JAMES RUSSELL, Wednesbury,
Mr. JOHN TAYLOR, Manchester,
Mr. J. B. TIERNEY, Tipton.

HONORARY MEMBER.

Mr. EATON HODGKINSON, London.

Mr. Fothergill said, he begged leave to intimate that it was his intention to retire from the Council, as he felt a disposition to make way for some one else, who would do his best to promote the interests of the Institution.

Mr. Clift said he had great pleasure in proposing a vote of thanks to the Council for their valuable services during the

past year. Owing to their great zeal and diligence, notwithstanding the hindrances that might have resulted from the lamented death of the President, everything had been done for promoting the best interests of the Institution.

The motion was seconded by Mr. HENRY SMITH, and passed.

The CHAIRMAN said, he had been requested by the Council to return thanks for the kind vote of confidence and approbation with which they had been favoured. He could say on behalf of himself and the other members of Council, that the time they had devoted to the interests of the Institution was a serious consideration to many of them, and as one of the early supporters and friends of the Institution, he could speak feelingly on that point; but though, with respect to those interests, they had laboured heartily and earnestly, they would be fully rewarded when they found the Institution take that position in the scientific world to which they considered it entitled, as the Institution of Practical Mechanical Engineers, (applause). He had now to bring before the Meeting some Papers, which had been supplied to the Council and approved for their consideration.

The SECRETARY then read the following paper by Mr. De Bergue, who pointed out the references on the drawing.

ON A STATION BUFFER.

AAAA represent the timbers forming the framework of the apparatus, BB being the main posts against which the pedestals of the cross shaft, or axle, are fastened.

C is a wrought-iron Shaft supported on a journal at each end; there are two Pinions DD on this Shaft, which are of wrought-iron, and cut out of the solid shaft; the centre of this shaft has a boss, a little larger in diameter than the outside diameter of the pinions, and upon this boss there is a cast-iron Friction Pulley, which is firmly keyed to it; the outside of this pulley is turned, and is surrounded by a friction clip EE.

The moveable Buffer rods FF are made of timber, and are furnished at the under part with two wrought-iron Racks, which are firmly bolted to them; these racks gear into the two pinions on the main axle; the pitch of the teeth is 1¼ inch, the breadth of the racks 5 inches, and the breadth of the pinions 5½ inches. Above the pinions and above the wooden buffer rods, two friction pulleys GG are placed to keep the racks properly in gear.

HH are two cast-iron Cheeks, resting at one end on the shaft, the other ends being firmly bolted to the ground; these cheeks are placed on each side of the friction pulley, the shaft revolving freely through them, but they act as levers to resist the revolving power of the shaft when it is set in motion; these cheeks are connected together at I by a strong cylindrical stay bolt, which passes through them both, and to this bolt I one end of the friction clip E is attached. JJ are two smaller cheeks, also held in their position by the bolt I, upon which they revolve freely. The other end of the friction clip E is attached, by means of a round bolt or stay K, to the lower extremities of these two smaller cheeks, as shown in the section.

L is a steel Spring, attached at one end to the two small cheeks, and pressing at the other end on the back of the wrought-iron curved Lever M; this lever is held at one end by the aforesaid bolt I, which passes freely through it, and upon which it can oscillate. NN is a cross beam made of angle-iron; this beam is fastened at the ends to the two buffer rods, and travels with them: on the centre of this beam, and just under the lever M, there is a small friction roller P, with a groove in it, in which groove the under and curved part of the lever M rests.

Now when the Buffers are driven up by the impetus of a body coming in contact with them, it is evident that the Racks, gearing into the Pinions on the shaft, will compel the Shaft and the Friction Pulley to revolve in the direction of the arrow, and that the friction clip will offer a resistance to the revolving of the friction pulley in proportion to the pressure or strain put upon it by the pressure of the Spring L, and this pressure may be regulated at will by means of the set screw O; but as the buffers proceed in their course, the grooved Roller P is carried forward in a horizontal straight line, and thus forces up the curved Lever M, which pressing harder on the end of the Spring L, keeps increasing the pressure on the friction clip, and in consequence the resistance of the Buffing apparatus.

The advantages of this Buffer are, that it is simple and most effective in its results, as it may be regulated to act with any desired amount of resistance; it occupies but little space, is not expensive, and has no recoil action.

The CHAIRMAN asked Mr. De Bergue if he could state the expense of one of these buffers fixed at a station.

Mr. DE BERGUE said he did not know exactly, but thought it would be about £120.

Mr. SLATE asked him to explain his view of the superiority of this buffer over the ordinary spring buffers.

Mr. DE BERGUE said, that in the ordinary buffers, the springs have to move through a great space, presenting very little resistance at first, and it was only when they were driven up considerably that they gave out their resistance; but when a train was stopped there was a certain quantity of momentum to be overcome at once. In his plan there was the advantage of the buffer being regulated to traverse as much as was required, and the amount of resistance regulated throughout; and then again there was no recoil of the buffer. A spring buffer could not be regulated in that manner, and there was the recoil of the springs to contend with.

Mr. ADAMS asked whether any member could give information about the Hunt's-Bank Station Buffer.

A MEMBER said, he believed it was made with a series of 4 double springs, and had about 6 feet length of action, and that it had no recoil.

The CHAIRMAN asked Mr. De Bergue what was the range of his buffer.

Mr. DE BERGUE said, the one shown in the drawing had a range of 8 feet, but he was making one like it for Mr. Fowler with 3 feet range.

The CHAIRMAN asked what range he would recommend.

Mr. DE BERGUE said, that must depend very much on the station; if it were an inclined plane, it would of course require a much more powerful one: he would propose 6 or 8 feet range for such a station as Birmingham. A spring buffer had no recoil when made with racks to hold back the springs when they were driven up; but if the catches of the racks gave way, there would be injury from the recoil. In his plan there was no recoil; the buffer was worked back by hand after it had been driven up.

The CHAIRMAN observed, that the advantage of the buffer appeared to consist in the ease with which it could be brought back to its former position without any recoil.

Mr. FOTHERGILL said, it appeared that the difference between the invention of Mr. De Bergue as represented there, and other plans in operation, consisted in the fact that in his plan it is

others it is accomplished by a series of
the springs produces re-action, whereas
coil of the buffer. In proportion as the
taken off, the amount of friction given
reased; and according to the weight of
on in which the buffer might be placed,
might be regulated in different instances,
tum to be overcome.

ked, that one objection struck him, that
ce had to pass through the shaft between
, and he thought that a sufficient friction
se the shaft to twist and break instead of
be overcome by having two drums, one
s reducing the length of the shaft; but
uld not, he conceived, possess any advan-
liptic-spring buffer already spoken of as
From what he had heard, he thought that
and effectual one, and it was provided
o hold any amount of strain that might
gs; he thought the catch was so simple
scarcely to be called an objection, a
ep down the catch, or it might be kept
here was a mode of bringing back the
description to Mr. De Bergue's plan;
ss shaft and a wheel with gearing intro-
ers, so as to take off the strain of the
; the catches were then lifted up, and the
and. He thought that was quite as effec-
De Bergue's buffer; but his impression
d not stand so severe a blow as a spring
ould, he thought the other would be pre-
expense, for he thought the elliptic-spring
ensive.

aid, that a much greater resisting power
is plan than by any spring buffer. If a
ing through 10 feet of space was to be
be overcome with the ordinary springs,

there were none made strong enough; but with his principle of friction it might be done. The most powerful spring buffers would not overcome more than 4 or 5 or 6 tons, but he proposed to begin with 3 or 4 tons, and to go on increasing it to 10 tons, or as much as the train of carriages could stand.

Mr. HODGE asked what he proposed to make the rack of.

Mr. DE BERGUE said, wrought iron, cut out of the solid.

Mr. HODGE asked if he did not think that with the percussive force of a train, proceeding at the rate of 10 or 12 miles an hour, the teeth would be stripped.

Mr. DE BERGUE did not think so, because it would be useless to put a strain on the friction drum sufficient to strip the teeth. A train running at 12 miles an hour could not be stopped in 8 feet.

Mr. HODGE observed, that he was doubtful of the resisting power of the teeth, on account of the sudden percussive force they would be subjected to; but he thought there was great range in the buffer, and approved of its principle more than of the spring buffer.

Mr. DE BERGUE said, that he calculated each tooth of the rack would stand a force of 20 tons.

The CHAIRMAN asked him to give the result of the trial of the buffer he was making for Mr. Fowler, when it was completed.

The CHAIRMAN then called upon Mr. Richmond to explain his Improved Engine Counter, which was exhibited to the meeting.

DESCRIPTION OF AN IMPROVED ENGINE COUNTER.

This Engine Counter is not brought forward as an original invention, but as an improvement on the engine counters previously used. The main points of improvement are the simplicity and certainty of the action; for however rapidly the Counter may be worked, it is impossible that the first, or units hand, can move more or less than one division of the dial for each stroke of the engine; and another improvement is the method of calculation adopted, all the hands revolving the same way. This Counter is much less expensive than those previously used, and it is now being generally adopted for marine engines going trans-atlantic voyages; the expense of the Great Western Counter was £25

price of this instrument is only £7, and it tells up
ther point of importance is the great expense in the
Great Britain steam ships of attaching the engine
shaft, whereas all that is required with this Counter
action of half an inch. There is also a security
reading off the counter, each dial keeping a check
en No. 1 has reached 100, No. 2 will have marked one
. 2 has reached 1000, No. 3 will have marked one
No. 3 has reached 10,000, No. 4 will have marked
at it is impossible that any mistake can occur in the
ontinually checks the next one.

IAN asked Mr. Richmond if he could give any
ecting their actual employment in any case.

OND said, one of them had been in use at the
Works for the last twelve months, and Mr.
ted that it had performed in the most satisfactory
s superior to any other description of counter
.

IAN asked if he could make one on that plan
ter the miles run by a locomotive engine, and
e injured by the ordinary jerking at a high rate
llisions of course excepted; and what would be

OND said he could make such a counter, but he
the number of revolutions that would be required
ell the expense. A counter registering 1,000,000
£7, but one registering 10,000,000 would be £8,
dial would have to be introduced.

remarked, that the principal point appeared to
orm of the escapement, affording a principle for
er velocities. In other respects it was as old as
ber, and he did not see anything new in it, but
ster the revolutions of a locomotive, it would do
ne had been able to accomplish before.

BOTTOM said, he was now applying an engine
omotive, but the difficulty he experienced was in
er of revolutions which a wheel makes in a given
ident that the motion cannot be given from the

driving wheels because of the slipping, and the other wheels make as many as 480 revolutions in a minute. There was therefore this great objection to it; but he proposed to derive the first motion from a worm on the axle of the wheels, with a vertical shaft to the counting apparatus, and attaching that to the ordinary gas meter dials, which he thought was quite sufficient.

Mr. RICHMOND observed, the hands of the gas meter dials did not revolve all the same way, as was the case in his counter, and that was an advantage in the latter.

The CHAIRMAN suggested that it might be worth his attention to see whether he could devise some plan for applying it to the purpose mentioned, as it was very desirable to have a counter for the number of miles run by a locomotive.

Mr. RICHMOND said, in answer to a question, that he had tried very great speed on his counters, but not so much as 400 strokes per minute.

Mr. FOTHERGILL said, in connection with this counter he would mention the counting apparatus generally used in cotton spinning machinery, which registers up to 4,000 in one revolution of the two discs; it is placed on a wheel which receives its motion from a pinion, and he had no doubt it would suit the purposes of Mr. Ramsbottom, and it would not be so bulky as this counter by one half.

The CHAIRMAN asked Mr. Whitworth if he had not some plan of counter.

Mr. WHITWORTH said it was very simple, it was a worm working in two wheels, and counted up as high as 30,000.

The SECRETARY then read the following paper by Mr. Hick, of Bolton.

ON A PATENT STARTING AND DISENGAGING APPARATUS.

This Apparatus is used for connecting and disconnecting steam engines or other motive power, with shafts and machinery, in such manner as to gradually transmit or withdraw the power required for driving the machinery, and modify the intensity of the shock caused by sudden connection or disconnection.

In cotton mills, where this apparatus has been applied to the lines

n, either to the driving wheels or to the first
advantages have been fully developed; it gives
ous disconnection from the main driving shafts,
y a child, and in many instances its adoption
prevent the frightful accidents which are so
ich are often aggravated by the want of such
time which takes place in communicating with
ng the whole of the engines and machinery.

lso peculiarly well adapted for bleachers, man-
, and dash-wheels, and is now extensively in use.

dvantageously to almost any machine, or in any
ommon catch box and friction straps are or can
applied to spur, bevel, or mitre wheels, or coup-
be made of any power or magnitude.

drawing shows five different modifications of the
be extended to suit peculiar situations.

represent the Apparatus as applied to a pair of
and this is equally applicable to spur wheels, or
n the driving Shaft A the Wheel B is keyed, that
, which is prepared with a projection D, and a
straps E, and runs loose upon the cross Shaft F
tion.

, with right and left-handed threads, and having
on the middle of each, work between the two
g Arms J, which arms are keyed upon the shaft
othed Quadrants K K, gearing into two toothed
t point to the centre of the Shaft; one end of
a Ring M, which slides on suitable keys in the
c., are carried round with the Shaft.

M is moved by Levers in the usual way as ap-
ch box. When the Shaft F, the driving Arm J,
nts, Pinions, Friction straps, &c., attached, are
and C, and Shaft A, only are in motion, and the
he length of the Rack, as shewn in the drawing.
ng Ring and Racks with the Levers, motion is
uadrants to the Pinions, and right and left-hand
the Friction strap, and gently and gradually
t A, and any machinery driven by it.

dopted or introduced into ordinary gearing now

at work, with very slight alterations in their present arrangement o[f]
ordinary catch boxes.

Figure 1 is a Sectional Plan.

Figure 2 is a Sectional Elevation.

Figure 3 is an End Elevation.

Figures 4, 5, and 6 represent the Apparatus as applied to a pai[r] of Bevel Wheels in an *internal form*, and this may be also applied to any other sort of Wheel or Coupling. A is the driving Shaft, upon which the Wheel B is fixed, working into the Wheel C, which is prepared with a projecting Ring D, and runs loose upon the Shaft F; inside the projecting Ring D is a driving Disc G, fitted and keyed upon the Shaft F, and this Disc is fitted with three expanding Segments H H H, lined with sheet copper, or other metal, to prevent the interior of the Ring D from galling, which copper, &c., may be replaced when worn. The expanding Segments H H H are secured to the Disc G at the centre of each by three projecting Driving pieces J J J, fitted and sliding freely in corresponding grooves in the Disc G, and each Segment has also two bolts K K, with nuts screwed against shoulders, and fitting slotted holes to admit of expanding, yet keeping the Segments H H H close to the Disc G. Also between the ends of each Segment there are three Screws L L L, with right and left-handed threads, fitted into suitable adjusting nuts, and from the middle of each screw a Lever M projects towards the centre of the Shaft F; each Lever is connected by a Link and pin to a Ring N, which slides upon suitable keys in the shaft F, and is carried round with it when in motion.

The sliding Ring is moved in and out by Levers in the usual way.

When the Shaft F and the driving Disc G, with its expanding Segments H H H, Screws, Levers, Links, and sliding Ring, attached thereto, are stationary, the Wheels only and the Shaft A are in motion, and the Ring D, with its Links, &c., will project out as far as the Levers and Links permit. By forcing up the Ring, motion is given to the right and left-handed Screws, which expand the Segments pressing their outer surface (which is covered with sheet copper, or other material) against the interior of the projecting Ring D with a gentle and gradual force, equivalent to the power required.

Figure 4 is a Sectional Plan.

Figure 5 is a Side Elevation.

Figure 6 is an End View.

Figures 7, 8, and 9 represent the Apparatus upon a very simple

plan of construction, which may be applied to Spur, Bevel, and Mitre Wheels, or Couplings for Shafts.

A is the driving Shaft, B a Spur Wheel keyed upon it, working into the Spur Wheel C, which is prepared on one side with a projecting Ring D, and runs loose upon the Shaft F, which is connected with the machinery to be driven. Upon this Shaft is keyed a driving Disc G, into the periphery of which, on opposite sides, two or more brass Slides H H are fitted into suitable grooves, and the outer surfaces of them are fitted to the interior of the Ring D, and extend about one-eighth of its internal circumference. Between these Brass Slides and the centre boss of the Disc G, are fitted two or four Screws J J, with adjusting nuts, and with a projecting Arm K K forged to the end of each Screw nearest the centre of the Shaft, but projecting outwards. A Ring M sliding on keys in the Shaft F (and carried round with it when in motion) is connected by Links and pins to the projecting part of the Screws J J, and is moved in and out by Levers in the usual way; giving motion to the Screws which press out the brass Slides or driving pieces H H, against the interior surface of the Ring cast on the driving wheel, and give the means of gentle and gradual motion to the machinery.

Figure 7 is an Elevation.
Figure 8 is a Sectional View.
Figure 9 is an End View.

Figures 10, 11, 12, and 13 represent the Apparatus applied in the form of a disengaging Coupling for a Shaft, and the same modification may be applied to Wheels, &c.

A is the driving Shaft; B a hollow Box or Disc, forming the exterior of the coupling and keyed upon the Shaft-end, its centre boss extending over the end of the Shaft A; into this a brass bush is fitted, and also the end of the driven Shaft C, which revolves freely therein. Upon the exterior of the centre boss belonging to the Disc B, are fitted two expanding Segments D D, with their external surface lined with sheet copper, and fitted against the internal surface of the outer Disc B. The Ring E slides upon suitable keys in the Shaft C, and is fitted with two hardened taper projecting Arms F F introduced between the Segments D D at opposite points, and fitted against adjusting screws.

The sliding Ring E, with its projecting Arms, is moved in and out by levers in the usual way.

When the Shaft C and sliding Ring E, with its projecting Arms and Segments, are stationary, only the driving Shaft A and the outer Disc B are

in motion, and the Ring E will project from the coupling about the lengt of the projecting Arms, but retains its hold of the Segments; by forcin the Ring E by the Levers as before mentioned, the segments expan against the interior surface of the outer Disc, and put in motion graduall the shafting and machinery required to be driven.

Figure 10 is a Sectional View through the centre of the Shafts.

Figure 11 is an Outside View.

Figure 12 is a Front View, with the sliding Ring removed.

Figure 13 is a Detached View of the sliding Ring.

Figures 14, 15, 16, and 17 represent the Apparatus in somewha similar form to the one last described, but modified so as to be applie to a pair of Bevil Wheels; the principal difference relating to th expanding Segment, which is made in three parts, and having thre corresponding tapering projecting Arms attached to the Sliding Ring.

The CHAIRMAN remarked, that in future papers it would b desirable to have the drawings on a larger scale, and the part well defined, so that the members in the distant parts of the roor might clearly understand them; and he hoped that this suggestio would be adopted by those members who might be preparin papers.

Mr. COWPER said, this starting apparatus appeared to b on the same plan as one used by Mr. Oldham, of the Bank o England. In the simplest form of the apparatus shown on th drawing, there were 3 segments made to fit into a box, and the were forced into contact with the box by a toggle joint moved b a lever; in the next form shown the segments were forced out b a screw, and in the other by a wedge. It was very like th expanding mandril, and he thought it the best kind of clutc ever made, and very easily managed.

Mr. BUCKLE said, it was the best contrivance of the kind tha he knew. They had a number at Soho, very similar in construc tion, from 12 to 36 inches in diameter, and they both engage and disengaged without the least noise or concussion. He ha used them with 4, 3, and 2 segments, and found that those wit 2 segments answered as well as the others; they had been used a Soho for 18 or 20 years. He had many objections to the ca and screw clutch, and the crab and cone clutch, as they made

great noise and concussion, and risked the breaking of the shafts. These objections led him to try the radial clutch with 8 segments, which answered the purpose in a satisfactory manner. He had since fitted clutches with 4 and 2 segments with equal success; those with 2 segments appeared to transmit the power as smoothly as the others with more segments. The radial clutch was, in his opinion, the best description of clutch that had been tried.

Mr. Hodge suggested that an engraving of these clutches would be very useful to the junior members of the Institution, and a valuable collection might be made of the various plans that had been invented for the purpose.

The Chairman observed, that there was now an opportunity for the junior members of the profession to be admitted into the Institution as graduates.

Mr. Slate asked what was the patent claim in Mr. Hick's clutch.

Mr. Fothergill said, he believed it was the application of this clutch in connexion with something else in calender dash wheels, and such kind of works, that constituted the patent claim.

The Chairman remarked, that there appeared to be no difference of opinion as to the merits of the clutch, independent of the question of originality.

The Chairman said, the next subject was a new improvement in Railway Chairs and Switches, invented by Mr. Baines of Norwich, which the Secretary would explain in the absence of the inventor.

DESCRIPTION OF BAINES' RAILWAY CHAIRS AND SWITCHES.

The first portion of this invention is an improved Joint Chair, the object of which is to prevent the joints from rising or getting out of line, and the rails from driving forward. The outer jaw of the chair, as shown in the accompanying specimen, fits close up to the under side of the head of the rails, but the inner jaw is only of sufficient height to clip the bottom flanch of the rail; and the rail is not fixed by a key, but by a square wrought-iron dowel-pin, which is passed through a hole in the outer jaw of the chair, and a corresponding notch in the end of each rail. This dowel-pin is 1¼ inch wide and ⅞ inch thick, and has a large flat

head, and under the head is placed a wrought-iron plate, 9 inches long, which fits close up to the head of the rails on the inner side, and rests on the chair. A square cotter is then driven vertically through the outer end of the dowel-pin, which draws the whole firmly up to the outer jaw of the chair; the wrought-iron plate is ¾ inch thick in the middle, tapered to the ends, and slightly cambered, and it is sprung flat by driving the cotter. This cotter is made long enough to drive through the bottom of the chair into the sleeper, and serve as the spike on the outer side of the chair; a slot is made in the upper part of it to allow of the cotter being drawn out when required, by inserting a lever in this slot. Two ordinary spikes are driven on the inner side of the chair.

The notches in the rail ends are made by a revolving cutter, which is shown in the accompanying drawing; the rail is laid in a cast-iron bed in the machine, and the cutter is made to a fixed guage, so that all the notches in the rail ends correspond exactly in size and position, and there is no difficulty in keying up the dowel-pin. This is made to fill the hole in the outer jaw of the chair, but only fits the bottom and one end of the notch in the rails, to prevent any weight coming on to it; and it does not interfere with the ordinary allowance for expansion between the rails. The cutting machine is in a portable form to be worked by hand, and the notches in the rail ends can be readily and quickly cut on the ground, with the same accuracy as those made in the manufacture of the rails.

The pressure of the wheels has no tendency to loosen the fixing of the rails in this chair, as it is all resisted by the chair, the outer jaw of which fits close to the head of the rails, and the bottom flanch of the rails is firmly clipped by the inner jaw of the chair. The dowel-pin does not receive any of the pressure of the wheels, but holds the rails firmly against the outer jaw of the chair, and prevents any risk of a foul joint occurring.

The dowel-pin also prevents the rails from rising at the joint, and from driving forwards; and the latter is an important advantage both for safety and economy, as the action of the trains running is continually driving the rails forward to so great an extent as to cause a considerable item in the expense of keeping the line in repair, to prevent the rail ends being driven out of the joint chairs, which would cause a serious accident. In the ordinary construction there is nothing but the friction of the wood keys to resist the driving of the rails; and the effect of the weather on the wood keys, alternately shrinking and swelling them, causes their hold on the rails to be gradually weakened.

r the head of the dowel-pin fits close up to the
ing drawn up tight against them, serves as a
the two rail ends stiffly together and prevent
This effect is shown in the two accompanying
rail connected together by these improved joint
ling rails connected by the ordinary chairs with
stiffly coupled together like one piece of rail,
loose at the joints.

joint causes one rail end to support the other,
g of the joint and the canting of the joint
e of every train; which is so serious an evil in
of permanent way, causing a shock at every
at passes over it, which weakens the tenacity
ne rails break at a short distance beyond the
smoothness of the road for travelling, as well
shes the expense of maintenance of the perma-
y of the long plate allows of the joint being
uired for slewing the road in laying or repairing.

this invention is an improved Intermediate
h is to fix the rail without the use of any key.
r are made exactly alike, and are set obliquely
h other, as shown by the accompanying specimen
is slipped endwise on the rail, and then twisted
which makes it grip the rail between the two
hair is forced tight against the rail on each side
ly by means of the spikes. These are screws
and the holes in the chair are made with an
ich is oval and eccentric at the bottom; so that
into the sleeper close to one side of the hole in
head is drawn home into the countersink, the
ound and increases the pressure of the jaws on
the spike heads are made with ¼ inch draught,
of the jaws, as shown by the accompanying
of three to one to increase the pressure on the
r fit close up to the head of the rail, so as to hold
but the yielding of the spikes in the wood
icity to prevent the road being too rigid. To
all made correctly to fit the rail, it is proposed
d pattern, a specimen of which is exhibited with

This chair prevents the rail working loose, as there is no wo
to get slack or lost out, and the spikes are screwed into the sleep
the constant serious expense of renewing the keys is avoided,
expense caused by the great number of chairs broken in driving t
which will form an important improvement in economy and safe

The only trial yet made of these improved Joint and Int
Chairs has been at Norwich Station, where a short length in
line has been laid with them for a few months, which has pr
satisfactory.

The last part of the present invention is an impro
Switches, which consists principally in making the tongue o
about an inch deeper than the main rail, so that the bottom
tongue works under the main rail. The bottom flanch is k
the end of the tongue without being cut, which adds mat
stiffness and steadiness of the switch tongue, by giving it a
to slide upon. Another object of this construction is to ma
clean itself in working, by driving the dirt under the mai
of against it, as in the old construction, where the tongue a
rail being of the same depth, the dirt gets pressed between th
ever the switch is worked and cannot escape, which is a great s
accident, by preventing the tongue from shutting close and causin
catch the flanch of the wheels. This is further provided for by the
of the seats of the switch chairs, which are made with a raised face
diagonal direction for the tongue to slide upon, and sloped off on all side
by means of which the working of the tongue continually clears the dirt
off the face of the chairs.

This switch is capable of being laid either right or left-handed, without giving up the advantage of having the long tongue to lead, because the two tongues are shaped exactly the same on both sides as the bottom flanch is not cut, and they will fit on either side; the only difference in changing from right-handed to left-handed being, that a slight bend of the tongue is required, which is done by the plate-layer in laying the switch. The point of the tongue is prevented from rising when a train passes over, by the bottom flanch of the tongue locking itself under the main rail.

The lever box shown in the accompanying model of the switch, is made to prevent the entrance of dirt, which accumulates in the present boxes on account of the large opening left in the cover for the lever to work through. In this improved lever box, the lever and connecting

INSTITUTION

OF

ANICAL ENGINEERS.

REPORT OF THE

OCEEDINGS

AT THE

GENERAL MEETING,

BIRMINGHAM, ON 25TH JULY, 1849.

CHARLES BEYER, ESQ., V.P.,

IN THE CHAIR.

BIRMINGHAM:
AMIN HUNT AND SONS, 75, HIGH STREET.
1849.

PROCEEDINGS.

THE usual GENERAL MEETING of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Wednesday, the 25th July, 1849; CHARLES BEYER, Esq., Vice-President, in the Chair.

The CHAIRMAN opened the proceedings by stating that he was unexpectedly called upon to preside in consequence of the unavoidable absence of Mr. Robert Stephenson, their President, who was engaged in giving evidence before the House of Lords.

The minutes of the last General Meeting were read by the Secretary, and confirmed.

The CHAIRMAN announced that the following books, &c., had been presented to the Institution during the present year:

Eaton Hodgkinson on the Strength of Cast-Iron, by the Author.
Barlow on Railway Wheels, ditto.
Dent on the Aneroid Barometer, ditto.
Bourne on Indian River Navigation, ditto.
The Practical Mechanic's Journal, by the Editor.
The Mechanic's Magazine, ditto.
The Civil Engineer and Architect's Journal, ditto.
A Marble Bust of Mr. George Stephenson, by Mrs. John Joseph Bramah.

The following paper by Mr. Ramsbottom, of Manchester, was then read.

ON AN IMPROVED LOCOMOTIVE BOILER.

Without discussing the merits of the various arrangements and dispositions of the working parts of Locomotive Engines, the author of the present paper proposes to make a few observations respecting the most vital part of these machines, that upon which the satisfactory performance of all the details must necessarily depend, namely, the Boiler.

Before proceeding to the immediate subject of this paper, it is proposed to point out one or two objections to locomotive boilers as at present constructed, which experience has brought under the author's notice; and then to describe a form of boiler which appears to him in some degree calculated to remedy the defects which will be referred to.

It is scarcely necessary to observe that the absolute power of a Locomotive, or any other steam engine, is strictly proportioned to the quantity of steam which the boiler of such engine can produce in a given time; and chemists are generally agreed that the quantity of atmospheric air required, (or oxygen which is the supporter of combustion), as well as the quantity of fuel, is in direct proportion to the quantity of water evaporated; or in other words, to produce more steam, it is not only necessary to supply more fuel, but also more atmospheric air in proportion to the quantity of steam produced.

It is well known that some of the Locomotive Engines built at the present day have from two to three times as much heating surface as those built about eight or ten years ago, and consequently when performing a proportionately increased amount of duty, they require from two to three times the quantity of air forcing through the fire in the same time.

The working parts of these Engines have also been increased in dimensions; the cylinders from 12 inches to 15 and 16 inches diameter, the stroke from 16 inches to 20 and 24 inches, and the driving wheels from 4 feet 6 inches to 6 feet diameter, and in many cases even more.

Notwithstanding all these enlargements and improvements there are however two elements which have been but slightly changed; namely, *the diameter of the blast pipe*, and the diameter of the *cylindrical part of the boiler;* and as the whole of the steam (after having performed its office in the cylinders) is driven in a forcible jet up the chimney for the purpose of producing the necessary draught through the fire, and as the power required to produce this jet is so much taken from the gross power of the engine, it follows that the smaller the blast pipe is in proportion to the total heating surface of the boiler, the greater will be the resistance to the action of the piston, and the greater the loss of power on this account.

From observations made upon Engines under the author's immediate superintendence, it appears that whilst the heating surface of Locomotive boilers has been increased from 400 square feet (in the year 1842) to 987 square feet (in the year 1846), the blast pipe has not been in the slightest degree enlarged, but on the contrary in the latter case has been reduced in area in the proportion of 12¼ to 8¼ square inches.

ing the total heating surface or *area of production*, as by the size of the blast pipe, or *area of eduction*,), the following very instructive results are obtained.

	When built.	Area of Blast Pipe.	Heating Surface.
....	1842	1	4608
....	1842	1	5044
....	1845	1	7961
....	1846	1	12960

t case, then, it appears that the heating surface has been y *three-fold* in proportion to the size of the blast pipe, as Engine No. 24 ; and the reason will be obvious when it the boiler No. 30 is only of the same diameter as the o. 24), and consequently that the flue room, (which as a vill be as the square of the diameter of the boiler), has htly increased, the extra heating surface having been d by enlarging the fire-box, by putting in a mid-feather, sing the length rather than the number of tubes.

necessary to enquire how far the diameter of the cylinders size of the blast pipe, nor to ascertain the amount of he blast pipe absorbs, though it may be stated that expe- it to range from 10 to 20 per cent. of the gross power of cording to the number diameter and length of tubes, peed of the engine. It may be remarked, however, that a degree of exhaustion is required in the fire-box under nstances equal to a column of water 4 inches in height, of exhaustion in the smoke-box must of course be greater he resistance offered by the tubes to the passage of the om the fire-box to the smoke-box.

eriments made about 2½ years ago upon an Engine with g surface of 987 feet, carrying 147 tubes of 1¾ inch eter and 13 feet 10 inches long, the author found that ce was at all velocities *three times* as great as the other words, that 66 per cent. of the total force of the ired to overcome the resistance offered by the tubes to f the heated gases, leaving 33 per cent. only to operate ; and it is this evil which results from the comparatively rea of the boilers as at present constructed, to which w more particularly called, and which it is proposed to manner now to be explained.

From what has been said it will readily be inferred that there is some difficulty in materially increasing the power of Locomotive Engines, as the necessary amount of heating surface cannot be obtained without increasing the diameter or the length of the boiler, or making it oval, to all of which plans there are some objections; but by the method now proposed it will be easy to enlarge both the fire-box and tube surface from 35 to 40 per cent., without increasing either the diameter of the boiler or its length, as will be now shewn.

It is proposed to construct the copper fire-box with an arched roof, the top of which shall be nearly as high as the top of the cylindrical part of the boiler, as shewn in the Drawing, Fig. 1, which represents a transverse section through the fire-box. This box may of course be made any length without sensibly reducing the strength of the roof, and will require none of the stay-bars which are so essential to the security of the flat-roofed box, and which for a moderate sized engine weigh not less than 400 lbs.

With such a box the whole of the cylindrical part of the boiler can be filled with tubes, and of course the whole of the longitudinal stays be removed; and in the present instance there are 225 tubes of 2 inches external diameter, the shell of the boiler being 3 feet 8 inches diameter and 10 feet long; the total heating surface of the fire-box is 80 feet, and of the tubes 1177 feet, making a total heating surface of 1257 feet.

Such an arrangement involves the necessity of keeping the boiler full of water, and it is therefore requisite that a separate steam chamber should be provided. This, as will be perceived from the Drawing, consists of a cylinder which is 13 feet long and 20 inches diameter, fixed over and parallel to the cylindrical part of the boiler, or, as it may now be termed, the generator. This tube, which has a cubic capacity of 28¼ feet, is connected at each end with the generator, as shewn in the Drawing at A B, Fig. 2, which represents a longitudinal section of the boiler. It is proposed that the water shall occupy about one-fourth of the capacity of this tube, leaving a clear space of say of 21 cubic feet for steam; this is rather more steam-room than most modern boilers possess, and for reasons which are afterwards mentioned, the author thinks it will be sufficient, although it may readily be increased by slightly enlarging the diameter of the steam chamber, which as at present shewn, is not so high as the ordinary steam dome by about 12 inches.

It has been proved experimentally by Mr. Robert Stephenson that the generative power of the copper fire-box is three times as great per

unit of surface as that of the tubes; and independent of this authority, Locomotive Engineers are generally agreed that the great bulk of the steam generated in a Locomotive boiler is formed upon the surface of the copper fire-box and the first 18 or 20 inches length of the tubes. As the whole of the steam has to rise through the body of the water, with which it is for the time mechanically mixed, and as the specific gravity of these mixed fluids will be much less than the comparatively unmixed water at the smoke-box end of the boiler, it follows that there will be a brisk circulation through the generator and steam chamber, in the direction indicated by the arrows upon the Drawing. The mixed steam and water will be driven into the upper vessel, and will there be effectually separated; the former passing off to the cylinders by the longitudinal pipe C D, Fig. 2, which has a number of small holes upon its upper surface, and the latter running again into the generator through the vertical connection at the front end, and thus keeping up the circulation.

That the specific gravity of the mixed steam and water at the fire-box end is often reduced to at least one-half that of water alone, is proved by the fact that the water guage will frequently show a downward current through the glass tube, even though the circulating fluids be one half water and one half steam, shewing as it does that the column of the mixed fluids (F G, Fig. 4) in the boiler is specifically lighter than the column H I in the glass guage; and from this fact it is also evident that this great expansion is confined to the water in the vicinity of the fire-box, since if it extended to the whole mass, the boiler would not contain the requisite quantity.

From the circumstance that no bubble of steam can rise into the steam chamber between the points marked A and B, Fig. 2, it is concluded that this boiler will not be so liable to prime as the common one, and therefore that the steam chamber as shewn is sufficiently large. As to the water surface, which in this boiler it may be objected is smaller than in others, it is conceived that the great facilities this boiler will give to the engineer for raising steam, will leave him comparatively at liberty to put in water when and where he chooses, and consequently that but little difficulty need be apprehended on this point. It is evident however that the objection may be fully met by constructing the outer fire-box with a pyramidical roof in the way so common.

In conclusion, the author would express his conviction that this boiler, combining as it does a great increase of heating surface, *and corresponding increase of flue area*, with a relative diminution of bulk and weight, and great simplicity of construction, is calculated to remove

some of the difficulties experienced by Locomotive Engineers, and promote the best interests of the Railway world in general.

The CHAIRMAN said, that in the unavoidable absence of M Ramsbottom, he would observe that his object in the foregoi paper was to obtain a considerably larger area of flue-room th in the present locomotive boilers, and to make a boiler of a lar heating-surface with less weight.

Mr. SLATE was of opinion that for the weight the engi carried, it would have a considerably greater effective heatin surface than any previous form of boiler; but he thought t boiler would have as great a tendency to prime as any other.

Mr. COWPER was also of opinion there would be a great te dency to prime in the proposed boiler; the surface from whi the steam had to rise was the entire surface of the fire-box a tubes, and all the steam had to pass through the two openin into the steam-chamber, and it appeared to him the water wou be carried up there in a complete state of froth.

Mr. McCONNELL, while agreeing to a certain extent as to t liability of the boiler to prime, thought it might be obviated having a more continuous communication between the generat and the steam-chamber; perhaps the steam-chamber could fixed close upon the top of the generator, and a continuous lon tudinal opening be made, communicating between them throug out their entire length. He thought the proposition of M Ramsbottom was a very good one, as it was a received opinion th the proportion of the flue-room to the fire-grate surface could n be too large, supposing that full advantage was taken of the fl surface before the heated air reached the chimney. Whether lo tubes or short tubes as applied to locomotives were most adva tageous, was a question not yet decided, and he thought they h scarcely data enough to determine as to the advantage of lo tubes on the ground of economy. It was a very important matt to determine what length of tubes was most advantageous for u in proportion to the area of the fire-grate.

Mr. C. COWPER was not aware whether there was a authority respecting the proportionate heating power of the tub and the fire-box, besides the experiment of Mr. Stephens alluded to in the paper.

Mr. McConnell remarked, that it appeared from experiments made by Mr. Stephenson and Mr. Beyer, that a very considerable heat was lost in the smoke-box even at the end of the longest tubes that were used; and he thought that the air in the centre of the tubes might have a considerably higher temperature than the air at the sides of the tubes, and that much of the heat might be carried through by a stream of air like a solid bar in the centre of each tube, without ever coming in contact with the sides of the tube, and consequently without being communicated to the water of the boiler. He had been informed that it was found to be a useful practice in marine and stationary boilers, to create a disturbance in the currents of air passing through the flues, for the purpose of mixing up the particles as much as possible; and a similar advantage might probably be obtained by mixing the air in the tubes of locomotive boilers.

Mr. Gibbons said, he had observed a similar advantage from mixing the particles of air in heating the air for his blast furnaces near Dudley; the pipes through which the air was passed for the purpose of heating it were bent like a syphon, so as to cause all the particles of air to come in contact with the sides of the pipes, and the air was found to be heated much more efficiently by these bent pipes than by straight pipes.

Mr. Allan said, he had tried an engine with a ½ inch iron rod fixed in the centre of each tube; the rods were as long as the tubes and supported at intervals by short projecting pins to hold them in the centre of the tubes. The engine had been worked with them for some time between Birmingham and Liverpool, but no difference was found in the working and consumption of coke, as compared with the same engine doing the same work without the rods in the tubes; the result was found to be exactly the same in both cases.

Mr. C. Cowper remarked, that the rods in the tubes would have the effect of contracting considerably the flue area, and increasing proportionately the amount of power requisite to draw the air through the tubes, and consequently the rods in the tubes would cause a loss of power to the engine from the increased resistance to the blast. He thought therefore the rods must have caused an equal amount of gain to neutralize this loss, by bring-

ing the air into more effective contact with the sides of the tube as the result showed no loss on the whole.

Mr. McConnell thought it was certain at least that the us of the rods did no harm; and it must either be considered tha there was no advantage in a large flue area, or that there wa considerable advantage in mixing the air in passing through th tubes.

Mr. Slate was of opinion, that even on the ground economy a large number of tubes was advisable, because with th violent and frequent action of the pieces of coke the tubes wer soon worn out; whereas by increasing the number of tubes th velocity of the draught would be diminished, and the tubes woul be less worn and would last longer.

The Chairman remarked, that the larger the area of the flu the better it was for the engine, as it must offer less resistance t the blast-pipe; but he was not certain what this resistance actuall amounted to.

Mr. Cowper said, that Mr. Daniel Gooch had found fro his indicator cards, that the resistance of the blast-pipe amounte to 11 or 12 lbs. per square inch, at a moderate velocity of abou 30 miles an hour.

Mr. McConnell observed, that as a certain quantity heated air had to be conveyed from the fire-box to the chimne and a certain area of heating surface was also required, the would be an important reduction effected in the resistance of t blast-pipe by increasing the number of tubes, so as to increa the area of passage and reduce the length of the tubes, diminis ing proportionately the resistance of the air passing through t tubes.

The Chairman said, he was present when the experimen were tried that were mentioned by Mr. Ramsbottom, to ascerta the difference between the degree of exhaustion in the smoke-bo and in the fire-box; the experiments were tried with a long boil engine, and a glass water guage was fitted into the smoke-b and another into the fire-box. The degree of exhaustion in t smoke-box averaged three times as great as that in the fire-bo and this proportion was found to be nearly the same at all vel cities; the greatest amount of exhaustion observed in the smok

lumn of water 13 inches high. He thought
ance of the blast-pipe and the back pressure
not amount to more than 15 per cent of the

rked, that assuming it to be 15 per cent, it
cent of the whole power of the engine was
ion of the air in passing through the tubes,
the smoke-box was three times as great as
e-third only of the pressure of the blast was
he fire-box.

L thought it was an important subject for
rtain the actual power lost by the resistance
ferent sizes, and under the different circum-
umber of tubes. In his own practice he had
bes and many of them produced the best
reducing the size of the tubes was their
ces of coke whilst working.

said, he thought there was some advantage
er proposed by Mr. Ramsbottom, and that
modifications that had been proposed of the
re was not one that was so likely to be useful.
ks was passed to Mr. Ramsbottom for his

aper by Mr. Benjamin Gibbons, of Shut End
was then read.

N A PNEUMATIC LIFT.

ift described in the present paper is employed to
limestone for charging four smelting furnaces at
rnaces, near Dudley.

the levels of the ground admit of the furnaces
ling the materials on a level platform from higher
he furnaces, but in general these have to be raised
vel of the top of the furnaces, the height raised
feet. The usual plan of raising the materials is
which rises from the ground to the top of the
f about 30 degrees; there are two lines of railway
ng platform on each line, drawn up by a steam

engine by means of a chain passing over a pulley at the top of th inclined plane. The two platforms balance one another, one of ther descending while the other ascends, and the top of each platform made horizontal and works level with the ground at the bottom and wit the stage at the top of the furnaces, so that the barrows of materials a readily wheeled on and off the platforms; several barrows are carried b each platform. A rack is fixed on the inclined plane along the centr of each line of railway, and a catch is fixed on the moving platfor which falls into the teeth of the rack in ascending, for the purpose stopping the platform and preventing an accident in the case of th chain breaking; but the use of this catch is found to be inconvenie in practice, and is generally omitted. There is a difficulty in stoppi the platform at the required level, and the inclined plane is objectionab from the space which it occupies and the expense of its construction.

Where the inclined plane cannot be employed, the power of th steam engine is not employed directly to draw up the materials vertical by a chain, because of the difficulty in working it conveniently an safely, to stop the platform at the correct level for wheeling the barrov on and off, and prevent the risk of serious accident by the chain brea ing, particularly in the night work. At some Iron Works an endle chain is used for this purpose with a series of buckets fixed upon i which are filled with the materials at the bottom and empty themselv into the furnace by turning over at the top. This lift is not suitable f supplying more than one furnace; and when there are more than o furnace it is most advantageous to employ a lift that will take up t materials in the barrows, ready for wheeling at the top to the differe furnaces.

Another plan for lifting vertically is by means of a water balanc the platform on which the barrows of materials are raised is suspend by a chain passing over a pulley at the top, and a bucket is attached the other end of the chain; the platform in descending draws up th empty bucket, and when the platform is loaded the bucket is filled wi water until it overbalances the loaded platform and draws it up. The is an important objection to this plan, that the bucket descends with a accelerated velocity, and a friction break has to be used to check th velocity to prevent a violent concussion on stopping its momentum the end of the descent; this causes a risk of accident from breaka of the chains, and the friction break is also liable to derangement a expensive repairs.

At the Level Iron Works near Dudley an instance occurred whe a vertical lift had to be introduced in consequence of the furnaces bei

raised 16 feet in height; there were two furnaces, originally 34 feet high and raised to 50 feet high, and at the original height the materials were wheeled on the level to the top of the furnaces. When the height of the furnaces was increased the materials were required to be raised 16 feet, and a vertical lift was necessary in consequence of the situation being so much confined by a canal as to prevent the adoption of an inclined plane. For this purpose the author of the present paper constructed a Pneumatic Lift, worked by the pressure of the air from the blowing engine that supplied the blast for the furnaces. This lift was designed with the object of avoiding the objections to the plans of vertical lifting previously in use, and obtaining a safer and more economical application of power.

This Pneumatic Lift consisted of a heavy cast-iron cylinder, 4 feet 4 inches diameter inside, closed at the top, and inverted in a well filled with water, in which it was free to slide up and down like a gasometer; this cylinder was suspended from the top by a chain fastened to the circumference of a pulley which was fixed on a horizontal shaft above the level of the top of the furnaces. A pipe from the air-main was carried down the well and turned up inside the cylinder, rising above the surface of the water, and when the blast was let into the cylinder through this pipe the cylinder was raised in the water by the pressure of the compressed air against the top; this pressure was about 2 lbs. per square inch. A platform for raising the barrows of materials was suspended by a chain from another pulley on the same shaft as the former pulley, and the platform was guided in its ascent by vertical framing. The cylinder was heavy enough to draw up the platform with the load upon it by descending into the water when the blast was withdrawn; and the empty platform was lowered by admitting the blast into the cylinder and thus raising it. The cylinder was lowered again by opening a valve which let out the compressed air, and its velocity of descent was regulated by opening this valve more or less. The velocity of the platform both in rising and falling was completely under command, by regulating the opening of the valves for admitting or letting out the compressed air, and the velocity was gradually checked towards the end of each stroke with certainty and ease, so as always to stop the platform without concussion. The height to which the cylinder was raised was only 5 feet, and the two pulleys were made of different diameters so as to raise the platform 16 feet; the load raised upon the platform was about half a ton. This Pneumatic Lift has now been in constant work for 39 years, and has worked quite satisfactorily during the whole time; it has not required any repairs except renewal of the

chains and repair of the rubbing parts. An accident happened once the chain breaking whilst lifting, and the platform fell about 5 fe causing a shock to the man going up with it, but no injury was done the machinery.

An improvement on this Pneumatic Lift was made by the author the present paper, in constructing a lift on a considerably larger scale the Corbyn's Hall New Furnaces; this is shewn in the accompanyi Drawing, and was constructed at the time of building the furnac The height to which the materials have to be raised is 44 feet 6 inch and the present plan was designed to prevent the risk of an accide occurring through the breaking of a chain. There are four furnac supplied by this lift, which is fixed between two of them, and the fo furnaces are connected on the same level by the staging at the top, which the barrows of materials are wheeled from the platform of the lift

In this lift the platform for raising the barrows of materials is fix on the top of the air cylinder, and it is raised by the pressure of t blast, the action being the reverse of the former plan. In the accor panying Drawing the lift is shewn at the highest position in Fig. 1, a at the lowest position in Fig. 2. A is the Air Cylinder, which is 5 fe 6 inches diameter and 51 feet 6 inches long, constructed of rivet wrought-iron plates averaging ¼ inch thick, the plates being $\frac{5}{16}$ in thick in the lower part and $\frac{3}{16}$ in the upper part; the cylinder is close at the top and open at the bottom, and has a Throttle Valve B, 8 inch diameter, in the centre of the top, which is opened by pressing dow the Foot Lever C fixed upon the platform.

D is the Platform on which the materials are raised; it consists planking carried on timber bearers, which rest upon the edge of t cylinder top, and upon four wrought-iron Brackets E E carried o diagonally from the cylinder to steady the platform, and fixed to tw hoops passing round the cylinder.

F F are four timber Guides placed at the corners of the platfor and connected at top to the level stage G G upon which the barro of materials are wheeled to the mouth of the furnace H. These guid are faced with angle-iron on the inner edge, and a corresponding angl iron is fixed in a notch at each corner of the Platform D, to slide easi up the guides; the height that the platform rises is 44 feet 6 inches.

Four cast-iron Balance Weights I I are suspended outside t Guides F F by chains which pass over the Pulleys K K in the to framing, and are attached to the four corners of the platform D. Thes four balance weights weigh about 6½ tons, and the air-cylinder an platform together weigh 7 tons; leaving an unbalanced weight of abou ½ ton to bring down the air-cylinder and empty the platform.

The air-cylinder A descends into a Well L L which is filled with water to the level M, and it is guided by four Rollers N N 6 inches long and 7 inches diameter, each of which works against a strip of bar-iron riveted on the cylinder, 4 inches wide and the whole length of the cylinder. At the bottom of the well a foundation of timber O is fixed, to form a stop for the cylinder in descending, and the cylinder rests upon the timber when at the lowest position by a ring of angle-iron riveted round the bottom edge. The cylinder is stopped on rising to the top by a wood block fixed on each of the four guide-posts F F, which stop the platform at the level of the top stage G G.

P is a cast-iron Pipe 7 inches inside diameter, which conveys the compressed air from the air-main, and the Pipe Q of the same size carries it into the cylinder, passing down to the bottom of the well between the cylinder and the side of the well, and rising up the centre of the cylinder; the end of the pipe at R is open and stands above the level of the water.

The Valve S regulates the admission of the compressed air into the cylinder when the platform is raised, and also lets out the air from the cylinder when it is lowered. This valve consists of a plug or deep piston sliding in a vertical bored cylinder of the same diameter as the air pipe, which is closed at the top and open at the bottom. When the plug is in the lowest position as shewn in Fig. 1, it closes the bottom of the cylinder and the communication is opened betwen the pipes P and Q. and the compressed air passes into the Air Cylinder A, and raises it with the Platform D, by the pressure of the air upon the top of the cylinder and upon the surface of the water; the pressure of the compressed air is 2½ lbs. per square inch, and the water is depressed inside the cylinder to T and raised to U outside the cylinder, making a difference of level of 5 feet 4 inches. When the platform is required to be lowered, the Plug Valve S is drawn up to the top as shewn in Fig. 2, closing the pipe P that admitted the compressed air, and leaving the pipe Q open to the external air to discharge the compressed air from the Cylinder A; this discharge is accelerated by opening the Escape Valve B at the top of the air-cylinder by means of the Foot Lever C.

The total pressure of the compressed air against the top of the air cylinder is 3¼ tons; and deducting the unbalanced weight of the cylinder and platform ¼ ton, this gives an available lifting power of 3 tons. The load of materials raised varies according to the working of the furnaces, and the average load of materials raised each time is 1½ tons, exclusive of the barrows and men, or about 2 tons gross weight. The lift is raised 16 times per hour during 20 hours in each day of 24 hours, or

once in 3¼ minutes; and the total weight of materials raised each d
is about 500 tons. The time of raising the platform from opening
inlet valve to reaching the top is from 50 to 70 seconds, according
the load in regular work; and the time of lowering the platform is fr
30 to 50 seconds according to the degree of opening of the escape va
on the top of the air cylinder; the empty platform can be raised in
seconds, and lowered in 25 seconds, with the present size of apertures

In raising the platform the inlet valve is kept full open until
platform arrives at 14 inches distance from the top, when it catche
lever which gradually draws up the plug of the inlet valve, so far
nearly to close the pipe leading to the air cylinder; this checks
moving power and causes the velocity of the platform to be so mu
retarded by the time it arrives at the top, that the platform stops d
against the wood blocks without any concussion being felt. The pl
form is held firmly up to these stops by the pressure of the air as lo
as may be required, without any recoil, and without requiring any catc
to hold the platform, as it cannot descend in the least unless the air
allowed to escape from the cylinder, and the supply from the air p
keeps it full in the case of any leakage taking place. When the pl
form is raised empty, a wood block turning on a pivot is slipped by
foot under the lever that closes the inlet valve, so as to begin clos
the valve sooner; this is adjusted according to the velocity of the asc
of the platform, and regulates the lifting power so as to prevent
concussion on stopping at the top of the ascent.

When the platform arrives at the top, the men who go up with
barrows, wheel them off to discharge the materials into the several f
naces; and as soon as the empty barrows are brought back, the platfo
is lowered by drawing up the plug of the inlet valve to the top, wh
shuts off entirely the supply of compressed air, and opens the exit be
the plug for the air in the cylinder to escape. This is done by the m
on the platform at the top by means of a rod from the valve carried
the framing; and the escape valve on the top of the cylinder is th
opened and kept open till the platform is near the bottom, when i
closed and the velocity of the platform is so much checked bef
stopping that scarcely any concussion is felt at stopping; it can ea
be stopped without any concussion.

The velocity of the platform is also gradually checked in descend
by the gradual immersion of the cylinder in the water, which redu
the unbalanced weight of the cylinder. The total loss of weight of
cylinder when at its greatest immersion in the water is ¾ ton, wh
reduces the effective unbalanced weight of the cylinder and platfo

from ½ ton to nothing; but the weight of the four chains amounting to ⅛ ton is added to the balance weights at the beginning of the descent, and is transferred to the platform at the end of the descent, and the result is that the moving power causing the descent of the platform is reduced ¼ ton during the descent, being about ⅜ ton at starting and ⅛ ton at stopping; this moving power can be altered as required, by altering the balance weights.

This lift was originally constructed to work only two furnaces, and the air pipe was only 5 inches inside diameter, and the time of raising the platform was usually 140 seconds; when the other two furnaces were added it became necessary to add a second air pipe of the same size, for the purpose of working the lift twice as fast; one pipe only is shewn in the accompanying Drawing, equal in area to the two actually employed. When the lift was constructed it was found that the well could not be made sufficiently water-tight, on account of a slight disturbance in the strata from the getting of the neighbouring mine, and an outer cylinder of similar construction to the air cylinder, was consequently sunk into the well; this outer cylinder having a close bottom, and holds the water in which the air cylinder works, like the tank of a gasometer.

The quantity of air blown into the cylinder each time of raising it is 1128 cubic feet, and the total quantity per day of 24 hours is 360,960 cubic feet, or about 12 tons weight of air; the total quantity of air blown by the blast engines is 16,185 cubic feet per minute, and 23,306,400 cubic feet or about 780 tons weight of air per day of 24 hours. The proportion of the total blast that is used by the lift is therefore as 12 tons to 780 tons, or $\frac{1}{65}$ of the whole, and consequently $\frac{1}{65}$ part of the total power of the blowing engines is employed in working the lift; there are two blowing engines employed. The pressure of the blast is 2⅓ lbs. per square inch, and the total engine power is consequently 165 horse power; and the air consumed by the lift being $\frac{1}{65}$ of the total blast, it follows that $\frac{1}{65}$ of 165, or 2½ horse power, is the power that is actually employed in working the lift; this power being a constant power acting during the whole day instead of acting merely at the times when the lift is rising. The actual power required to elevate the lift, with the average gross load of 2 tons on the platform, or 2¼ tons total weight, including the average unbalanced weight of the cylinder and platform, raised 44 feet 6 inches in 70 seconds, is 6 horse power; the greatest power employed being 3¼ tons raised that height in 70 seconds, which amounts to 9 horse power, and the least is ¼ ton raised in 45 seconds amounting to 1 horse power. Thus it appears that the work of 6 horse power occurring at intervals, is performed by a power of 2½ horse power constantly acting.

The total consumption of coal-slack by the blowing engines is
13 tons per day of 24 hours, consequently the expense of workin
lift is $\frac{1}{65}$ part of this, or 4 cwt. of coal-slack per day, costing
5*d.* per day; and as this lift raises 500 tons of materials per d
follows that 100 tons are raised 44 feet 6 inches high for 1
4450 tons are raised 1 foot high for 1*d.* The quantity of air re
to fill the cylinder of the lift is 1128 cubic feet, and the total co
of the blowing cylinders for one double stroke is 1056 cubic feet;
sequently an increase in the rate of the engines of one strok
minute is sufficient to raise the lift in 70 seconds, without dimini
the supply of air for the blast of the furnaces.

These two circumstances cause an important economy in wo
this Pneumatic Lift; a small power constantly acting is sufficient
the work, and the sudden application of this power concentrated i
short time causes but a small increase in the rate of the engine.
total cost of this lift was about £500; and the cost of an inclined
lift, including the engine for working it, would be about double
amount.

This Pneumatic Lift has been in constant work for the last 9 y
and no accident or stoppage has occurred with it, except that the
of one of the balance weights broke once; the platform stopped w
very trifling fall, and was held in its position by the pressure of the
no damage was caused, and the lift was got to work again withi
hour's time. The only repairs that have been required since it
menced working, are the renewal of the chains of the balance we
and repair of the pulley bearings; the set of chains can be take
and replaced whilst the lift is standing during the dinner hour, wit
causing any delay to the work. This is an important advantage,
is essential to ensure a continued supply of materials to the furn
and to avoid any risk of stoppage for repair of the lifting machinery

The platform in this Pneumatic Lift cannot fall quicker than
time in which the whole body of air can escape, amounting to
cubic feet; and the greatest leakage that can arise from an injury of
cylinder cannot let it down so rapidly as to cause any damage.
load is supported by an air cushion during the whole time of its as
instead of depending on chains or racks, which prevents any risk o
falling. The complete control over the motion of the platform tha
given by the air valve which regulates the entrance and exit of the
gives the means of checking, stopping, or reversing the motion at
part of the stroke; and it prevents any concussion at the ends of
stroke, although the lift has a quick action, and is stopped dead at

end of the stroke at the exact level required. The friction of the lift is very small, as the cylinder works through a water joint; and in consequence of the low pressure at which it is worked the loss at any leak is very small, and the strain upon the joints is much diminished.

This Pneumatic Lift is of course applied most economically and conveniently in the case of Blast Furnaces, where the compressed air can be obtained very economically and without additional machinery; but it is probable that its application may be extended advantageously to several other cases, such as raising Railway waggons, or even Railway trains, discharging vessels at quays, and various other purposes, and it possesses several advantages which make it deserving of consideration. The low pressure at which it is worked causes great simplicity and economy in the construction and working, the loss at leaks being reduced, and the joints easier kept in order; and the friction is very small as the cylinder works through a water joint. Where the lift is not required to be always working, but only to be worked at intervals, a further economy could probably be effected by employing a reservoir for the compressed air, to accumulate power during the time that the lift is not required to work, and thus reduce the size of engine requisite for the work; a large capacity of reservoir could be constructed at a moderate expense, on account of the low pressure upon it. It may be mentioned that at the Corbyn's Hall New Furnaces the reservoir of compressed air contains 5000 cubic feet at the pressure of the blast, $2\frac{1}{4}$ lbs. per square inch, and consists of four wrought-iron cylinders from 6 to 8 feet diameter, constructed of riveted plates from $\frac{1}{8}$ to $\frac{3}{16}$ inch thick; and the cost would be about £3 per 100 cubic feet for air reservoirs of this construction.

Mr. Buckle observed, that he had frequently seen this lift at the works of Mr. Gibbons, and could bear testimony to its smooth and exact working and its uniform motion. He was of opinion it might be usefully applied to a variety of purposes, as it was undoubtedly the best description of lift that he was acquainted with for its present purpose.

The Chairman said, it appeared to him to be a very simple and efficient mode of raising the materials.

Mr. Cochrane observed, that a similar lift was employed at his Iron Works, for which he had been indebted to Mr. Gibbons; it had proved entirely satisfactory, and there had never been any accident with it.

Mr. Gibbons remarked, that his object in bringing the lift

before the Institution, was to render it more generally useful ; f in his opinion it might be advantageously applied to a gre variety of purposes, more especially at railway stations and in t docks. It would be a great convenience for raising and loweri trucks, and for loading or discharging vessels ; as the platfo could be quickly raised or lowered to any exact level, and cou be stopped at any point at pleasure without concussion, and he quite firm in the position without any danger of falling, as lo as might be required.

Mr. Slate thought it was applicable to lifting railway wa gons ; and considered that a small blowing engine might advantageously employed for the purpose, working at a mu quicker rate than usual, even 700 feet per minute, like the pisto of locomotive engines ; the leakage of the piston would then of much less consequence.

Mr. Cowper suggested that steam might be available for t purpose of raising the lift where there was not a blowing engi at work ; for although there would be a loss of steam by conde sation on the surface of the water, that loss would be very sma compared to the whole quantity of steam employed, as the surfa of the water would become quickly heated by the steam, but t heat would only extend very slowly downwards in the water.

Mr. Gibbons remarked, that he considered there would be difficulty in applying steam from the difficulty of keeping t joints steam-tight.

Mr. McConnell referred to the use of hydraulic cran which had been introduced at some railway stations and oth places ; and observed that it appeared to involve the question the relative cost and advantage of air and water as the means f communicating the power.

Mr. Gibbons observed, that the pistons necessarily used hydraulic cranes were liable to get out of order, and were a sour of expense and trouble, and there was also a considerable loss power from friction, which was not the case in the pneumatic li He thought that by the latter plan a whole railway train mig be raised a considerable height, without the motion being felt the passengers.

A vote of thanks was passed to Mr. Gibbons for his co munication.

The Secretary then read the following paper, by Mr. Fairbairn, of Manchester.

ON THE EXPANSIVE ACTION OF STEAM, AND A NEW CONSTRUCTION OF EXPANSION VALVES FOR CONDENSING STEAM ENGINES.

The innumerable attempts that have been made to improve the principle of the condensing Steam Engine since the days of its celebrated inventor Watt, have almost all of them proved failures, and have added little if anything to the claims, next to perfection, of that great man's ideas. It would be idle to speculate upon the various forms and constructions from that time to the present, which have been brought forward in aid of the original discovery of condensation in a separate vessel. All that has been done is neither more nor less than a confirmation of the sound views and enlarged conceptions of the talented author of a machine which has effected more revolutions and greater changes in the social system than probably all the victories and all the conquests that have been achieved since the first dawn of science upon civilized life.

It would be endless to trace the history of the successful and the unsuccessful attempts at improvement which for the last half century have presented themselves for public approval; suffice it to observe, that no improvement has been made upon the simple principle of the Steam Engine as left by Watt, and but few upon its mechanism. Among the latter may be enumerated the improvements in the construction and mode of working the Valves; and of these the D Valve by the late Mr. Murdock, and the use of Tappets as applied to the Conical Valves, appear the most prominent and the most deserving of attention.

In the construction of the parallel motion, the application of the Crank, the Governor, and the Sun and Planet motions, all of which have risen spontaneously from the mind of Watt, there is no improvement. The principles upon which all of them are founded have been repeatedly verified beyond the possibility of doubt, and their mechanism is at once so exceedingly simple and so ingeniously contrived as to limit every attempt at improvement in those parts of the Steam Engine. What appears to be the most extraordinary part of Mr. Watt's Engine is its perfect simplicity, and the little he has left to be accomplished by his successors.

It will be in the recollection of most persons conversant with the Steam Engine, that the hand gear for working the valves by the air-pump or plug-rod, gave a self-acting and continuous motion to the

machine; and the facility which these means afforded for movin the Engine in any direction and at any required velocity, gave it degree of docility and power beyond the expectations of its mo sanguine admirers.

For a considerable length of time the hand gear was the best an most effective mode of applying the motion of the Steam Engine to t Valves; subsequently the oscillating and revolving Tappets, fixed upo a shaft and driven by wheels or an eccentric, came into use, and b means of vertical rods communicated motion to the valves, and th a similar effect was produced as by the hand gear; next came M Murdock's D Valve and eccentric motion, which for simplicity h never yet been equalled. The D Valve, and the flat plate Valve, a nearly synonymous, with this difference only, that the D Valve press with less force upon the face, and consequently works easier than t flat valve, which in every case is exposed to the full pressure of stea It is true that means have been adopted to obviate this objecti in large Engines, by a preparation on the back of the valve, which made steam-tight, and by a communication with the condenser, vacuum is formed over a proportionate area of surface, sufficient equalize the pressure and admit an easy motion of the valve.

The expansive principle upon which Steam Engines are n worked, and the economy which this system has introduced in the exp diture of fuel, has effected considerable changes in the working of t Valves, and has rendered the D and plate Valves almost inadmissa for such a purpose. To the skill, ingenuity, and careful attention the Cornish Engineers, we are indebted for many of the improveme connected with the use and application of expansive steam; and tak into account the high price of coals, and the urgent necessity economy in those districts, which combined with a system of regis and encouragement held out by premiums as described by Mr. Jo Taylor, we may reasonably conclude that other parts of the kingd have been greatly benefitted by the excellent examples set before th by the Cornish Miners and Engineers.

For a great number of years, and up to a recent period, Economy of Steam and the working of the Steam Engine expansiv were but imperfectly understood in the manufacturing districts; a although the Cornish miner set an excellent example and exhibite saving of more than one-half the fuel, there were nevertheless few if a attempts made to reduce what is now considered an extravagant exp diture in most if not the whole of our manufactories. But in fact subject was never brought fairly home to the Millowners and Ste

ıntil an equalization or reduction of profits
 saving attainable by a different system of

verage or mean expenditure of coal per indica-
puted at from 8 to 10 lbs. per horse power per
er 5 lbs. per horse power per hour in Engines
vely, and even then they are far below the duty
ish Engine, which averages from $2\frac{1}{2}$ to 5 lbs.
r.

the consumption of coal may be attributed to
conditions under which the duty of the two
rnish miner and the Manufacturer) are respect-
first being chiefly employed in pumping water,
rnate action in overcoming the inertia of a large
when once in motion is easier continued, for a
ntinuous power of resistance, such as exhibited
Mills. Another cause is the greater care and
rnish man pays to his boilers, steam pipes, &c.;
xposed, but are carefully wrapped up in warm
d, to prevent the escape of heat. Even at the
ntable to see (in the Coal and Iron Districts) the
waste that is continually going on, for want of a
tion in this respect; the only excuse is the cheap·
that is not an excuse, for if one-half can be saved,
t at 1s. per ton, it is certainly desirable to save
illing, when that can be accomplished at a trifling
f the chief, if not one of the most important
e of economy in fuel, is the reduction of profits
ured by power; under these circumstances, a
s a consideration of some importance, and to these
be traced the powerful stimulus which of late
ent in that direction. The low rate of profit in
ions, and a desire to economise and reduce the
a minimum, has been of great value in its ten-
t in the economy and efficient use of fuel, and also
essure steam and its expansive action when applied
. In France and most other parts of the continent
long in use, and although its effects as well as its
ong known in this country, it was only within the
he benefits arising from it were appreciated. For a
ars a strong prejudice existed against the use of

high pressure steam, and it required more than ordinary care in effecting the changes which have been introduced: it had to be don cautiously, almost insiduously, before it could be introduced. Th author of this paper believes he was amongst the first in the Manufacturing Districts who pointed out the advantages of high pressure steam when worked expansively, * and for many years he had to contend wit the fears and the prejudices of the manufacturers, before the presen system of economical working was adopted.

The first attempt was by improvement in the construction o Boilers, † and subsequently in the Valves of the Steam Engine, adapte to either low or high pressure steam when worked expansively; the latte of which it is the principal object of the present paper to develope.

The Expansive action of Steam has been variously estimated b different writers, but all seem to agree in opinion that a considerabl saving is effected by that process. It therefore becomes a question o importance in a community whose very existence almost depends upo the Steam Engine, how to work it advantageously and at the leas possible cost. The great variety of schemes and forms which hav been adopted for the attainment of these objects have been exceedingl various, ingenious, and interesting; and the investigation of the differen theories and applications that have been submitted for public approval would form an exceedingly attractive if not a useful history of th various discoveries to which we are in a great measure indebted for th present improved construction of the Steam Engine.

The elastic force and expansive action of steam were well know to Mr. Watt and some of his immediate contemporaries and successors such as Smeaton, Cartwright, Woolf, Trevithick, and others; but th fears entertained of explosion at that early period, and the difficulty o constructing vessels strong enough to contain high pressure stean were probably the greatest drawbacks to its introduction. Woolf an Trevithick were probably among the first to grapple with this dangerou element; and the former in order to economise fuel introduced th Double-Cylinder Engine, whereby a great saving was effected by increasing the pressure of steam in the boiler, and allowing it to pas from one cylinder to another of three or four times the capacity, b which its volume was expanded, and by these means a saving wa effected and an extra duty performed. If, for example, taking a Double

* See Paper read before the Geological Society of Manchester in the year 1840, on th Economy of Fuel.

† See Report on the Prevention of Smoke and Economy of Fuel.—Transactions of th British Association, 1844.

igh pressure cylinder being $\frac{1}{4}$ of the capacity of
the steam is condensed, there will be for one
an expansion of four times its volume, this of
ed pressure in the ratio of the capacities of the
ring this with a similar process in a Single
city to the two Cylinders, and fitted with a well-
regulated so that only one-fifth of the contents
n capacity to the small cylinder on Woolf's plan)
qual density, and the remaining four-fifths (equal
cylinder) is allowed for expansion, it is evident
being thus suddenly cut off from the boiler after
ed through only one-fifth of the length of the stroke,
hen used in completing the remaining four-fifths
result must be nearly the same as that obtained
on Woolf's plan. The advocates of Woolf's sys-
n its superiority, not from the actual force given
in favour of the single cylinder than the double,
eased condensation in the steam passage between
from the superior action and greater regularity of
rmer case is produced. To some extent this is
y appreciable amount provided the Fly Wheel is
he pressure and power at which the Engine is
le Engines which are now in common use, that
Engines are coupled together with the cranks at
other, there is less occasion for a heavy fly wheel,
expansion is less felt, if not effectually neutral-
erefore, of the Double-Cylinder Engine and the
g at equal rates of expansion, are virtually the
and economy of fuel, if the comparison be not in
ngine.

he conclusion that the same duty can be performed
e compound Engine, and considering the impor-
licity in mechanical construction, in opposition to
ngeniously contrived, it becomes a question how
as well as a simple process for the attainment of

was by revolving Tappets, which had been long
ormed and regulated in such a manner as to cut
a point of the stroke, as to give the exact quantity
These Tappets, to say the least, were from various
as the weight of the vertical rods and the slowness

of motion prevented them from producing the desired effect. T Steam Valves could however be fixed so as to cut off the steam at t required point of the piston passage in the cylinder, but the moti is not effected with the velocity essential to an efficient process expansive action. Other processes have been tried for working Stea Engines expansively besides those already noticed; amongst them m be noticed the equilibrium Valve, worked by double cams from t Crank Shaft. This method is generally used and adapted to the Mari and old Engines, but its application is seldom of much value unless t Engines and Boilers are capable of bearing a pressure of 15 lbs. 20 lbs. on the square inch.

Another fault to which this description of Valves is subject is th distance from the Steam-ports into the Cylinder, and the large quant of steam which occupies the space between the cut-off valve and t working cylinder of the Engine. To remedy these defects, and apply a better system of expansion to the common Condensing Engin the following apparatus and mode of working the valves was introduce

In giving a description of this effective and simple apparatus, it but fair to state that the first idea of this invention was suggested Robert Brownhill, at first imperfectly constructed, but since grea modified and perfected by the author of the present paper.

The annexed Drawings represent the cylinder and side pipes o sixty horse-power Condensing Engine. Fig. 1 is a front view of t Steam Chests and Cylinder; Fig. 2 a side view; Fig. 3 is a section the side pipes, Steam Chests, and Valves; and Fig. 4 an enlarged se tion of the Valves: the letters referring to the different parts are t same on all the figures. It will be observed that the Cylinder A, t Steam Chests C D, and the side pipes F G, are common to eve Engine of this description; the internal construction of the Stea Chests, Valves, and the mode of working, are peculiar and constitu the chief merit of the invention.

In the construction of a Steam Engine, two important conside tions present themselves, the attainment of a maximum of force, a the minimum in the consumption of fuel; to acquire the first it requisite to form such an arrangement of the working parts, as to obta the closest approximation to a perfect vacuum under and above t Piston, and the other is accomplished by having as small an expenditu of steam as possible. These desiderata are to a great degree attain by the principle upon which these Valves are constructed, and the w in which they are worked. Referring to Fig. 3 it will be seen that ea of the Steam Chests C D contains two double beat Valves S T, al

nd the Throttle Valve Q; these valves constitute
ngs by which the steam is admitted and returned
Valves S S next to the Steam Pipe E are the
am is admitted to the Cylinder, and the Valves
the valves by which the steam escapes from the
ser. All the four valves are of the same area
he steam valves are not lifted up so high as the
ne reasons which are afterwards given. The
s at C D, F G, &c., exhibit the passage of the
the Cylinder, and its ultimate escape at H to the
ble beat Valves of this construction have certain
e upper portion being larger than the bottom, in
1.000. The object of this enlargement of the
e being to give a preponderance to the pressure of
side, in order to overcome the pressure of the
g box which embraces the spindle, and to assist
f the valve in its descent when liberate dfrom the

orking the valves is by the Shafts and Wheels
awing I K L, they derive their motion from the
olve at the same speed; the vertical Spindle I I,
Circular Discs P P are fixed, passes through the
nd by its rotary motion the Cams which are fixed
aise the valves as they pass under the Rollers N N,
o the valve spindles by the cross heads M M, and
lves are raised and retained open or shut for any
Rollers N N are steadied by the cross heads M M
cal guide rods O O at their outer ends, and sliding
vertical grooves in the centre boss U, which is
le arms O O.

gine economically much depends upon the pressure
e amount of expansion given to the valves; the
ork with steam at 15 lbs. on the square inch and
e stroke, and expand the other half; but in other
gines and Boilers are calculated to bear a high
ay from 30 to 40 lbs. on the inch, the cams are
ff the steam at $\frac{1}{3}$ or $\frac{1}{4}$ of the stroke. As is shewn
P, there are generally three and sometimes four
the Discs, so as to cut off the steam at one-half,
rth, or at any other point corresponding with the
nd the load respectively.

To obtain this range of expansion the Rollers N N which work th
Steam Valves are moveable, by brass strips which slide in the groove
in the cross heads M M, so as to bring the Roller over any one of th
Cams that may be required; and the fixed Pointers V V show by
graduated scale on each brass slide, the exact point of the Cylinder a
which the steam is cut off, and by these means the extent of expansio
is regulated and brought under the eye of the Engineer.

It has already been stated that the Steam Valves are not lifted s
high as the Exhaust Valves, and the reason of this is, that as th
exhaust valves are not variable in their action, and always require fu
openings into the Condenser, it is desirable to retain them open through
out the whole length of the stroke. This process is effected with
greater degree of certainty than by any other description of valve; th
exhaust valves are raised suddenly by the short inclined planes of th
cams, and having allowed time for the escape of the steam from th
Cylinder through a wide passage into the Condenser, they suddenly fa
by gravitation, and thus a more complete vacuum is formed under th
piston than is probably attained by any other process.

The working of these valves is effected with a degree of certaint
and simplicity which renders them very satisfactory both as regard
their efficiency in conducing to the economy of steam, and the perfe
ease with which they are worked.

The CHAIRMAN observed, that the principal part of th
improvement described in the paper, appeared to consist in th
arrangement for effecting the expansion action by cams revolvin
horizontally.

Mr. W. SMITH said, he had seen several engines workin
with this expansion gear, and could testify to the superiority o
their action, the expansion gear was very simple and worke
exceedingly well; he had taken indicator diagrams from th
engines. He was not acquainted with any cases where this pla
had been at work for a long time, and he had some doubts as
the lasting of the parts.

Mr. McCONNELL remarked, that was a matter on which the
could scarcely express an opinion unless furnished with accura
data respecting the working. The Cornish engine reports we
very complete as to the performance of the engines and the co
sumption of fuel; and if they had such information with referen
to the working of the invention in question, it would be high

important as regards the improvement of the engine and its economical results.

Mr. Cowper suggested the desirability of making a collection of indicator diagrams in the Institution, and expressed his willingness to co-operate with other members in supplying some.

Mr. W. Smith said, it was his intention at an early meeting to lay before the Institution several hundred indicator diagrams which he had taken from engines in Staffordshire and the surrounding district.

Mr. McConnell observed, that the meetings of the Institution would afford parties connected with large manufacturing establishments an excellent opportunity for comparing the working results of engines in full action, not only in Staffordshire, but in Lancashire and other districts, and it was desirable that this class of information should be as perfect as possible.

Mr. Slate thought the diagrams referred to would read an important lesson to the parties employing steam engines, and induce them to look after their own interests and not waste their power. He had seen a number of Mr. Smith's indicator diagrams, and the results of them would surprise many; most of them showed a very inferior action, and some showed only 5 lbs. per inch of vacuum with 13 lbs. per inch of steam, but there were a few good diagrams amongst them.

Mr. Gibbons remarked, that one important thing they would have to attend to was the description of fuel used, which varied so greatly in Staffordshire as to render it a matter of great difficulty to collect accurate data.

Mr. W. Smith thought it very desirable to know the description of fuel and the consumption, wherever it was practicable; but all that he proposed at present was to lay before the Institution diagrams exhibiting the economy of the engine, and not the consumption of fuel.

Mr. McConnell suggested that they should not confine themselves to the relative economy of the different constructions of engines, but they should also take into consideration the different constructions of boilers and the relative consumption of fuel for the power produced, as well as the kind of fuel employed. He saw no reason why the reports of engine performance should

be confined to Cornwall, for it would be highly important t
have them for the various other districts, more especially Stafford
shire, Lancashire, and Newcastle.

Mr. GIBBONS remarked, that this would be extremely diffi
cult to obtain in Staffordshire, because the quality of fuel varied t
an extraordinary extent. In that district they had a considerabl
boiler surface, and in many cases used only coal-slack for fuel
which was good for nothing else; but in Cornwall the quality o
fuel was tolerably uniform, and the best qualities of coals wer
used.

Mr. SLATE proposed to omit the consideration of the con
sumption of fuel, as the fuel was not bought in the coal district
but merely taken from the heap as required, and it would not b
practicable in most cases to obtain any accurate return of th
consumption.

Mr. W. SMITH said, the question of fuel could not be in
cluded in the iron districts because it was customary in man
cases to generate the steam by the waste heat of the puddlin
furnaces, and in consequence those cases would shew no consump
tion of fuel; but on the contrary, in other cases the consumptio
was greatly above the usual proportion, either from the inferic
quality of fuel used, or from the engines being often worke
much below their boiler power, and wasting from the boilers eve
more steam than was used.

The CHAIRMAN observed, that it took a great deal at first t
induce the proprietor of a steam engine to look well after it
working, but in Manchester considerable attention was now pai
to the subject. There were many works where the consumptio
was as low as 4 lbs. per horse power per hour, but he should sa
that the average of Lancashire engines was twice that amount c
consumption if not more.

Mr. McCONNELL thought that was a strong argument fo
taking up the question in the broad view; for without considerin
any particular district, it was very important for a manufactur
or other proprietor of a steam engine to know what his engin
was doing as compared with the engines of other parties. Thos
engines in the same town or district could be fairly compared, an
any particular causes for exception could be stated in the return

Mr. Slate observed, that there were a few pumping engines in Staffordshire which were worked by contract, and their fuel was all measured, so that the consumption could be correctly ascertained; but those engines were an exception in the district.

The Secretary then read the following paper by Mr. David Burn, of Newcastle.

ON THE SYSTEM OF VENTILATION IN THE WALLSEND COLLIERY.

The Wallsend Colliery is situated about 3½ miles to the east of Newcastle-upon-Tyne. It is celebrated for having been the source of immense wealth to its late proprietors; and from the acknowledged superiority of the coal produced from this mine, arose the practice of appending the term "Wallsend" to such coals as were considered suitable for household purposes, indicating the class to which they belonged.

The seam of coal known by the name of the "Bensham Seam" is found in this Colliery, at the depth of 145 fathoms from the surface. Since the opening out of this seam twenty-nine years ago, there have been several explosions of Fire-damp, attended with a great loss of life, fully but unhappily entitling it to the appellation of a "fiery mine." In the course of working this seam, the following explosions and loss of life have occurred, from its opening to the present time.

In 1821	...	1 explosion		...	52 lives lost.	
„ 1832	...	1	ditto	...	1	ditto
„ 1835	...	1	ditto	...	102	ditto
„ 1838	...	1	ditto	...	11	ditto
Total		4 explosions		...	166 lives lost.	

The total thickness of the seam is 5 feet 8 inches, and it is divided by a band 8 inches thick, consisting of argillaceous shale and splint coal, the coal being 3 feet thick above this band and 2 feet thick below it; the roof consists of argillaceous shale. The quantity of coal raised annually from this seam is about 68,000 tons; but this quantity is considerably less than the powers and means of the Colliery are capable of producing, owing to the present depressed state of the coal trade. There are generally employed in the mine at one time about 210 men and boys, and 15 horses. Another seam of coal, the "High Main Seam,"

is situated 34½ fathoms above the "Bensham Seam;" this was firs opened out in 1781, and it was abandoned in 1831; during that perio five explosions occurred in working the seam, causing the loss of 2 lives.

There are five Shafts sunk to the Bensham Seam, as shewn on th accompanying Plans, Nos. 1 and 2, which are drawn to the scale of chains per inch; No. 1 is a Plan of the Workings, and No. 2 a Plan o the Ventilation, shewing the several currents of air that are passe through the mine. The shaded portions of the workings shows wher the coal is entirely removed. In the two Shafts C and D the ai descends into the mine, and after circulating through the workings i the manner hereafter described, it ascends in the Shafts A, B, and F A furnace is constantly burning at the bottom of each of these thre ascending shafts, to produce the draft of air and keep up an uninterrupte ventilation; these furnaces are 8 feet wide and 6 feet long, and each o them consumes about 1½ tons of coals per day. The descending Shaft C and D vary from 7½ feet to 10 feet in diameter, and the ascendin Shafts A, B, and F, from 5½ feet to 8 feet in diameter.

The Workings of this mine are divided into nine Districts, num bered from 1 to 9 on the Plan, which have in most cases distinct current of air for their ventilation, and are in some degree unconnected wit each other; a system which was carried out to a great extent in thi Colliery by the late Mr. John Buddle. The five Districts, Nos. 1, 2, 3 4, and 5, which are supplied with air from the Shaft C, are all coloure Red on the Plans; and the three Districts, Nos. 6, 7, and 8, supplie with air from the Shaft D, are coloured Blue. The general course o the air currents is shown in the Plan of the Ventilation, No. 2, by Re lines for the C shaft ventilation, and Blue lines for the D shaft ventila tion; and the detailed course of the air through the workings is shew by the arrows in the Plan of the Workings, No. 1.

The following are the particulars of the quantity of air that is circu lated through each of the Districts. The currents were measured wit Biram's Patent Anemometer; and on the day of measuring the quantit of air passing in each of these currents, the Barometer at the surfac stood at 29.35 inches, and the Thermometer at 53 degrees; the win South-East, morning dull with the appearance of rain.

In the following description the "Pillar Workings" are where th whole of the remaining part of the seam of coal is in course of bein extracted. The "Air Crossings," where one current of air crosse another current, consist of a brick arch or a timber erection, by means o

of air passes underneath and the other current above, unication between the two currents.

of Air descending the C shaft consists of 75,960 cubic and is distributed in the following manner. At a short shaft, at the point marked K on the plans, the first urrent takes place; 22,010 cubic feet of air per minute e "First District," which, after ventilating the passages and the workings at the northern extremity, is again oint marked L; 10,400 cubic feet per minute passing shaft and over its furnace, and the remaining quantity feet per minute passing into and circulating through ming the "Second District." On leaving this district, e "Third District," it is joined by another current, e main column of air at the point M, and consisting of et per minute; this augmented current is then carried kings of the Third District, and thence over the furnace the F upcast shaft.

ning quantity of the principal column of air from the duced to 43,450 cubic feet per minute, is again divided , where 15,750 cubic feet per minute passes into the ct," ventilating the Pillar-working P, and passing from F Shaft by an inclined drift, entering the shaft at the 60 feet from the bottom, and consequently not passing g furnace. The passing of this current of air into the ts coming into contact with the furnace, is rendered its being on many occasions mixed with Fire-damp, or drogen to the exploding point, caused by the discharge the falling of the roof, and eruptions from the thill or e coal seam.

naining column of air 7,500 cubic feet per minute is and along the Pipe-drift or Gas-drift R, to the B upcast in its passage the leakages of gas from the stoppings or the dormant or Pipe District, No. 9, and the discharge old workings S, near its southern exit to the shaft. And et per minute is passed through the workings of the and thence to the F shaft; 7,200 cubic feet of which urning furnace, and the remaining 13,000 cubic feet per e bottom of the shaft without passing over the fire.

ng is a summary of the different divisional currents of the aggregate column descending the C Shaft:—

	Cubic per mi
1st and 2nd Districts	22,0
3rd ditto	10,5
4th ditto	15,7
5th ditto	20,2
Pipe-drift to the B Shaft	7,5
	75,9

The quantity ascending the F Shaft being as follows :—	
1st, 2nd, and 3rd Districts	22,1
5th ditto	7,2
The quantity passing over the fire being....................	29,3
Add the quantity passing into the Shaft without going over the furnace :—	
4th District entering the Shaft by the inclined drift mentioned before	15,7
5th District entering at the bottom of the Shaft	13,0
Total quantity ascending the F Shaft	58,0

The column of air descending the D Shaft consists of 45,400 cu feet per minute, and is diverted into the following Districts, ascend at the A and B upcast Shafts.

	Cubic per mi
The quantity of air passing into the 6th District, ventilating the workings on both sides, and carried to the B upcast Shaft..	17,4
The quantity of air carried into the 7th District and Pillar-workings P, and passing by an inclined drift into the A upcast Shaft, evading the furnace	16,8
The quantity passing through the workings of the 8th District, and mixing with the various discharges of Gas from the old workings T T, in its course to the A Shaft ; being also joined by the current from the 7th District before arriving there	11,2
Total quantity descending the D Shaft	45,4
Ditto descending the C Shaft	75,9
Making a total quantity of air descending into the Bensham Seam of	121,3

coal field which this system of Venti-
prises is about .... 400 Acres
Workings of the 9th District, which
l and closed up to the Gas Pipe in the
described afterwards, is about .... 50 Acres

Total area......... 450 Acres

th of passages or Air-channels ventilated by the
ly enumerated, amount to about 24 miles in the C
miles in the D Pit Workings.

ity of air circulating through the passages of this
74,758,400 cubic feet per day; and the cost of
s, including their consumption of coals, amounts to
£347 per annum.

hanges of the atmosphere, as indicated by the Baro-
e effect of charging any of the currents proceeding
f the whole mine (or air passing over the furnaces),
appreciable degree; but under like circumstances
e Pillar-workings and the Pipe-drifts, are generally
h Carburretted-hydrogen, relieved by the change of
e from its vast magazines or gasometers formed by
the seam of coal.

am of coal, and situate to the east and south of the
District, coloured Green on the Plans, which is a
lying dormant, being closed off from the ventilated
a line of Stoppings or substantial brick walls. The
s generated in this district is a pipe O carried up
the surface, where the gas burns with great bril-
measured, the quantity issuing from this pipe was
5 cubic feet per minute; an amount nearly equal to
n of the town of Newcastle.

the idea was entertained of lighting the town of
gas generated from this source; but on experiment-
at its illuminating power was so exceedingly low,
ly useless as an economic light. However, since the
eased the Colliery, the attention of Dr. Richardson,
t of Newcastle, has been called to the subject, the
that he suggested the use of a very simple and cheap
g a large quantity of carbon, by passing the gas
lluminating power was raised to a point fully equal
—together with a large increase in volume. The

quantity of gas might be increased to a great extent by barring off a
piping the gas from other parts of the mine; and the subject of ben
ficially employing the gas is at present under consideration.

The following is the analysis of the gas issuing from the gas-pi
in the C shaft, and the gas evolved from the Workings of the Bensha
Seam; vide the Reports of Sir H. T. De la Beche and Dr. Playfair.

	Pipe.		Workings.
Carburretted-hydrogen	92.8	......	73.9
Nitrogen	6.9	......	24.9
Carbonic Acid	0.3	......	1.2
	100.0		100.0

Since the present proprietors commenced working this mine
1847, they have instituted the general use of the Davy-lamp, to prov
not only against the ordinary risks of the working of a "fiery min
but also the risk from sudden eruptions or discharges of gas, now w
known to have caused so many of the great explosions that have u
happily occurred in this Coal District.

Appended is a copy of the rules and regulations, which are stric
enforced, respecting the use of the safety-lamp, and the precautions
prevent the risk of explosion in the working of this Colliery.

Rules and Regulations to be observed by the Officers and Workm
of the Wallsend Colliery.

Any person observing any door standing open that ought to be sh
any stoppings injured, brattice knocked down or broken, or any ot
circumstance whereby the ventilation of the Mine may be deranged
obstructed, is immediately to inform the Overman or Deputy or ot
person then in charge of the Pit.

No Hewer to commence working in any place until it has first be
examined by the Overman or Deputy or other authorized person.

No Workman to work in any place where he considers the timb
&c., insufficient to support the roof of the Mine, or any other cause t
may render the place unsafe, until the Deputy or other person has m
it secure.

The Overman, Deputies, or other Inspector appointed for that p
pose, shall carefully examine and lock every Lamp previous to its be
taken from the "Cabin" or "Station," and any person having an i
perfect or broken Lamp is not to be allowed to pass to his employm
until he shall have given a satisfactory reason for any such damage; l

essness or neglect, he is not again to resume work until
fore the Viewer.

n who has the use of a Lamp shall take home the
the purpose of its being properly cleaned before it is

on any pretext, to leave the "Cabin" or "Station" until
ier Inspector has examined and found his Lamp to be

to hang their Lamps at such a distance from where
as to prevent the possibility of their being injured by
coal or other casualties.

Pony Driver, or Helper-up, is, under any pretext what-
Lamp during his work; a sufficient number will be
ng Roads to afford light for the performance of the work.
seeing another using his Lamp in an improper manner,
d to inform the Overman or other person in charge of

are hereby strictly prohibited from interfering in any
amps, further than the necessary trimming of the Wick

losing his light is to send his Lamp out by the proper
for that purpose, but not to be again used until it is

or other Workman getting any Blower or sudden Dis-
or observing, by the usual indications, the presence of
mmediately to draw down the Wick of his Lamp, and,
-damp inside the Gauze continue to burn, to protect it
by his clothes or other means, to apprize the Men and
ear him, that their Lamps may be likewise extinguished,
the fresh air by the Intake Air-course, if possible, until
other person then in charge of the Pit is informed of it.

acting contrary to these Regulations shall be immedi-
m his employment, fined, or prosecuted according to
tion of the Owners or their Viewer, the safety of the
rkmen depending upon the strict observance of these
all parties are enjoined to aid in the detection of any

r observed, that he was aware such an application
posed of the waste gas from coal mines, but it was
be of sufficient illuminating power for use in light-

ing a town. The plan suggested to obviate this defect was b charging it with coal-tar naptha, for the gas generated in the min was the sub-carburretted hydrogen, and was deficient in the ele ment of carbon; hence though it burnt very freely it yielded bu little light. If however, it could be collected in sufficient quantit and with due regularity, it might easily be rendered available fo street illumination by putting a small sponge-box on the burne and by the gas passing through a sponge saturated with naptha would acquire considerable brilliancy. There was at the prese time a similar discharge of gas in the neighbourhood of Wes Bromwich, but in that case also there was a deficiency of illum nating power.

Mr. GIBBONS expressed a doubt whether the plan of workir the mine as detailed in the paper was not inferior in economy ar efficiency to the mode adopted in Staffordshire; and he thoug if the number of shafts were increased the facilities for ventilatic would be much greater. He stated that his coal mine was ve tilated easily by a stream of air along the face of the working with several outlets at the top for the gas to escape; a gre portion of the gas was carried in a stream at the top witho mixing with the air, on account of its lightness, and a mu less quantity of air was required in proportion in consequen of the gas being so much less diluted with air. In that ca however, the seam of coal was very much thicker; the to thickness of the seam was 24 feet, and it was worked in tv heights of 12 feet each.

Mr. SLATE remarked, that the collieries in the North we of much greater extent than those in Staffordshire, which we usually not more than about 20 acres in extent; the former we also generally of greater depth, and sinking the shafts was ve expensive and difficult on account of the depth and the hardne of the strata.

Mr. CLIFT observed, that the excellent plan of ventilatic which had lately been introduced, of using jets of high-pressu steam to propel the air through the workings, was found to very successful. He had employed steam jets for the purpose emptying gas-holders, and he was astonished at the short time which the gas could be expelled from a large gas-holder by th means.

n then announced that the Ballot lists had
e Committee appointed for the purpose, and
ew Members were elected.

MEMBERS.

Benjamin Best, Dudley,
William Courtney, Dublin,
Jonathan Harlow, Birmingham,
Samuel McCormick, Dublin,
Walter McLellan, Glasgow,
James A. Shipton, Manchester.

an also announced that the meeting of the
n for the Advancement of Science, would be
m in September next.
nks was passed to the Chairman, and the pro-
d.

y B. HUNT AND SONS, HIGH STREET, BIRMINGHAM.

INSTITUTION

OF

CHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

D IN BIRMINGHAM, ON 24TH OCTOBER, 1849.

ROBERT STEPHENSON, ESQ., PRESIDENT,

IN THE CHAIR.

BIRMINGHAM:
BENJAMIN HUNT AND SONS, 75, HIGH STREET.

1849.

PROCEEDINGS.

al General Meeting of the Members was held
e of the Philosophical Institution, Cannon Street,
on Wednesday, the 24th October, 1849; Robert
Esq., M.P., President of the Institution, in the

ites of the last General Meeting were read by the
confirmed.

irman announced that, according to the Rules of
n, the President, Vice-Presidents, and five of the
d go out of office at the end of the present year,
he present meeting the Council and Officers for the
ear were to be put in nomination. He then read
list of Members whom the Council proposed for

President.

Robert Stephenson, Esq., London.

Vice-Presidents.

Three of the number to be elected.

Charles Beyer, Esq., Manchester,
William Buckle, Esq., Birmingham,
J. E. McConnell, Esq., Wolverton,
John Penn, Esq., London,
Joseph Whitworth, Esq., Manchester.

Council.

Five of the number to be elected.

Charles Beyer, Esq., Manchester,
William Buckle, Esq., Birmingham,
Thomas Cabry, Esq., York,
J. E. Clift, Esq., Birmingham,
William Hartree, Esq., London,
P. R. Jackson, Esq., Manchester,

J. E. McConnell, Esq., Wolverton,
John Penn, Esq., London,
J. Scott Russell, Esq., London,
Archibald Sinclair, Esq., Glasgow,
William Weallens, Esq., Newcastle-on-Tyne,
Joseph Whitworth, Esq., Manchester.

TREASURER,

Charles Geach, Esq., Birmingham.

SECRETARY.

W. P. Marshall, Esq., Birmingham.

No other names having been added by the Meeting, the li was adopted.

The CHAIRMAN then called on Mr. Samuel of London, read his paper,

ON THE ECONOMY OF RAILWAY TRANSIT.

The object of the present paper is to show that the Locomotiv now in use on most of the railways have outgrown the wants of t Passenger Traffic, and that the weight on the driving wheels of the locomotives, amounting in some cases to 14 tons, is perfectly unnecessa for the number of passengers conveyed in 99 cases out of 100.

For the purpose of obtaining practical data upon this subject, t writer of the present paper procured a return of the number of Passe gers conveyed on the Eastern Counties and Norfolk Railways, bo Main Line and Branches, by each train during the week ending 7 May, 1849; this return showing the greatest number of passengers each train at any one time.

It appears from this return that the greatest number of passeng in any Main line train at any one time was 231, and the least numb 7; the greatest number in any of the Branch line trains being 82, a the least number 3.

And by another return from the books of the Company it appe that there were conveyed on the Eastern Counties Branch Lines duri the year 1847, 42,644 tons of Passengers (calculating each passen with his luggage at 168 lbs.), and that the weight of Engines a Carriages required to convey them was about 1,112,500 tons, being the proportion of 26 to 1.

On examining the Coke Returns it also appears that the M line engines consumed from 24½ to 40½ lbs. per mile, and the engi

anch line trains consumed from 16½ to 35½ lbs. per
ourse with the size of the engine employed to do the
engines invariably consuming the smallest quantity of
work done. The average consumption of coke during
g 4th July, 1849, was 31½ lbs. per mile for Passenger
lbs. per mile for Goods engines.

efer to a stock of about 200 engines, and a length of
miles.

iter came to the conclusion that it would be possible
rriage and Engine combined, of sufficient capacity for
nd by his advice the Directors of the Eastern Counties
ers to Mr. Adams to construct such a carriage, subject
f Mr. Hunter, the Locomotive Superintendent.

e was accordingly built, and called the "Enfield," from
h she was intended to work.

m shows the "Enfield." The Engine has 8 inch cylin-
ch stroke; Driving Wheels 5 feet diameter; distance
20 feet; width of Framing 8 feet 6 inches. The
rdinary locomotive construction, 5 feet long by 2 feet 6
The Fire-box is 2 feet 10½ inches by 2 feet 6 inches.
115 tubes of 1½ inch diameter and 5 feet 3 inches in
total of 230 feet heating surface in the tubes. The
box is 25 feet, giving a total heating surface of 255 feet.
of this Steam Carriage is 15 tons 7 cwt. in working
ine and Carriage being combined, it is evident that the
iving wheels is increased by the load carried, and that
ases in the same ratio as the load required to be taken.
e distance between the centres of the leading and trail-
20 feet, accounts for the steadiness of this machine;
no perceptible oscillation when travelling at the highest
verifies the observation "that the steadiness of an
not on the position of the Driving Wheel, but upon the
ectangle covered by the wheels." This Engine at the
traverses curves of 5 or 6 chains radius.

ield" Steam Carriage was originally intended to convey
but as it was found that when she was put on as an Ex-
passengers increased in number, a "North Woolwich"
ached capable of conveying 116 passengers, and also a
Van, making provision altogether for 150 passengers,
r regular train taken at a speed of 37 miles per hour.

ine commenced her regular work about eight months

since, and the following return shows the miles run and coke consume by this Engine during the 7½ months regular working from Januar 29th to September 9th, 1849.

14,021	total miles run.
705	hours, running time.
1,457	ditto, standing time.
2,162	total hours, in steam.
743	cwt. coke consumed in running.
408	cwt. ditto standing.
286	cwt. ditto getting up steam.
1,437	cwt. total coke consumed.
11·48	lbs. per mile average consumption of coke.

The "Enfield" is in steam 15 hours per day, the fire being lighte about six in the morning and drawn at ten o'clock at night. But o these 15 hours it appears by the return that she is engaged runnin only 5 hours, the remaining 10 being employed standing in the siding It was found by experiment that the quantity of coke consumed standin was 32 lbs. per hour, and after deducting this and the quantity con sumed getting up steam, it will appear that the actual consumption o coke running is under 6 lbs. per mile.

It must also be particularly borne in mind that this consumption o coke includes the total Goods and Coal Traffic on the Branch, amount ing to 1410 tons; viz., 169 tons of goods and 1241 tons of coal.

The "Enfield" Steam Carriage worked the 10 a.m. Passenge train from London to Ely on 14th June, a distance of 72 miles, takin behind her three of the ordinary carriages and two horse-boxes; sh arrived at Ely 8 minutes before time, and the total consumption of fuel including the getting up steam, was found to be 8¾ lbs. per mile. Th tubes of the boiler are only 5 feet 3 inches in length, and the econom of fuel is consequently scarcely at the maximum.

Another Engine on a similar plan to couple with a 40 feet carriag is now nearly ready, the tubes being 6 feet 6 inches long, from which i expected even more economical results.

The result of the writer's experience is the conviction, that fo Express purposes, and for the larger portion of the Branch Traffic o railways, the light Steam Carriage is the best adapted and most econo mical machine, both as to first cost compared to the work done, and in working expenses.

Permanent Way are also very much reduced, as
.

analysis of the question appears to be as follows:
ed for the transit of passengers and goods; for
pable of division into small parcels, some latitude
may be allowed; for the former, the stature and
a fixed standard. The carriage in which men
fty enough to permit of standing upright when
the rich and economy to the poor, as a larger
ed standing than sitting in a given space. The
he *width* must be so proportioned as to exceed
ne-third in order to induce steadiness, bearing in
ay Carriage there are two bases, the "Spring
on the Axles, and the "Wheel Base" of the
To secure a sufficiently wide "Spring Base" the
ted beyond the wheels, and in practice a body 9 feet
where the width of the railway in centre and side
ut this width being obtained, it becomes essential
length to insure steadiness. Practice has verified
unties Railway, where for two years past carriages
wide, on 8 wheels (30 feet from centre to centre),
he most difficult curve and gradient in England,
being 189 feet.

area per wheel—the minimum of dead weight
l and the carriage, with least resistance to traction
result of this is, that the minimum of steam
raw it.

certain than that the number of travellers by
y the facilities given for travelling. If a large
s a given sum, and the departures are every two
Engine and Train could be divided into four, and
e every half hour at no increase of expense, it
at the passengers would double their numbers;
emonstrated that the expense would be lessened,
rangement the total dead weight is much reduced.
Counties Railway an Engine and Tender of say
, a First Class Carriage, and three Third Class
ay 120 passengers, make a total weight of 59 tons,
of coke, as has already been shown, is on the
nile. A Steam Carriage weighing only 17 tons
e number of passengers at from 7 to 8 lbs. of coke
st proportions are attained.

The first cost of a large Engine, Tender, and four Carriages h
been £4000. The Steam Carriage for the same number can be ma
for something less than one-half the cost.

The value of the Railroad in lessening draught consists in i
perfect horizontal level, and not merely its general level, but its clo
approximation to the character of a lathe-bed—a hard, inflexible, smoot
true, and equable surface.

With heavy Engines having 5 tons weight or more on each drivi
wheel, it is impracticable to maintain any road that it is possible
construct in this condition; for supposing the timbering to be of su
cient surface, and the rails to be perfectly inflexible girders with the
joints unyielding, the very iron itself will abrade beneath the tread
so heavily loaded a driving wheel, which whether of 8 feet or of 30 fe
diameter, can only rest upon a mere point.

It is a matter of doubt whether more than 3 tons can be placed
a wheel at great speeds without destroying the metal.

But there is yet another question to consider. In order to start
train into motion a great amount of power is necessary, many tim
greater than that which is requisite to keep up motion.

This surplus power remains in the train under the name
momentum; and it must be obvious that the greater the total weig
of the train the greater must be the momentum. If the road be in b
condition with loose joints, the momentum essential to the maintaini
of motion is consequently absorbed by these concussions. In short, t
joints are a series of holes, and many of our railways, relatively to t
heavy engines traversing them, are practically worse roads than a we
made macadamised road is to a stage coach.

If thus the weights be reduced below the point which cau
destruction, it is probable that the heavy item called "Maintenance
Way," and the still heavier item of replacement of rails, chairs, a
sleepers will nearly disappear.

Mr. Samuel further explained the diagrams illustrating
paper, and remarked that the Fairfield Steam-carriage on t
Bristol and Exeter Railway, had hitherto been worked with
upright tubular boiler, which had not proved satisfactory, and t
regular working of the engine had been prevented by the difficu
in keeping the tubes tight; but a horizontal boiler had been su
stituted, and the engine was just starting to work with it.

The Chairman remarked, that the subject was one of gr
importance, and he hoped it would give rise to an interesting d

; into any unfriendly difference of opinion, but
friendly difference.

ELL said, the results given by Mr. Samuel in
l proof of great economy; but how far this
niature engine might be brought into use on
l, must be determined by actual experience to a
n was yet afforded. He believed that the branch
ield engine had been running was as favourable
the engine as any that could be selected. He
an opportunity of travelling on the engine from
ld, when the performance was very satisfactory
iveyed; but any increase of load or additional
c would materially affect the performance of the
with a just appreciation of economy it had been
ly as possible to the load expected.

ld in the general management of railways ascertain
er of carriages required for the accommodation of
at economy of locomotive power might be effected;
y, in practice, they were often required to provide
a maximum of power for a minimum of traffic.
ot that the circumstances of many railways, par-
se districts where the traffic was nearly uniform,
em to adopt a power more nearly corresponding to
to the loads they had to take; for undoubtedly
any engines at present at work very far exceeded
rements. He agreed with Mr. Samuel that this
the rails must materially affect the question of
permanent way; and as the quantity of coke
standing and getting up the steam are expenses
nding all engines, he thought Mr. Samuel was
taking credit for economy. He was not, however,
how far this description of engine might be made
should be very glad to see any effectual step
y in the expenditure of railways, and he thought
erved great credit for having made such an effort.

ble to the subject, he recollected that on the Bir-
Gloucester Railway it was found desirable to employ
power for the purposes of traffic on the small

branch line from the main line to Tewkesbury, and for this pu-
pose he adapted one of the small American engines by combini-
the engine and tender on one frame, and by putting a tank on t
top of the boiler. But the gradients were very abrupt comi-
out from Tewkesbury, and when they worked the goods and pa-
senger traffic together they were frequently obliged to increase t
number of carriages, and in some cases the power was insufficie-
The engine had 10½ inch cylinders, with 4 feet driving whee-
and 20 inch stoke; the consumption of coke was from 15 to
lbs. per mile; and the gradients varied from 1 in 300 to 1 in 8
The pressure, however, on the American engines was very fal-
cious, for the spring balance only indicated about one-third of t
actual pressure on the boiler, which was really about 100 lbs. p
inch.

Mr. ADAMS of Birmingham remarked, that the Enfield engi-
was all on one frame with the carriage; but a different arrang-
ment was adopted in the Cork and Bandon engine, in which t
engine and carriage were on separate frames; and he enquired t
reason for adopting the former plan in the Enfield.

Mr. SAMUEL explained, that as the length of coupling of t
engine wheels in the Enfield was only 5 feet 4 inches, with an 8 in
cylinder, it was necessary to attach the carriage and engine on o
frame, otherwise it would be too short to run steadily; the eff-
produced by the carriage was like the stick of a rocket in steadyi-
the motion. But in the Cork and Bandon engine with a 9 in
cylinder, the length of coupling of the wheels was 10 feet, a
no carriage was required to produce steadiness, as the rectang-
on the rails was so much longer. In the case of large engin-
where the distance between the axles had been increased to 16 fe
a greater steadiness was observable.

There was accommodation in the carriage for 15 first cla-
and 116 other passengers, giving a total accommodation for 1
passengers; and this he considered the most serviceable for wor-
ing the express traffic. One of these Steam-carriages was bei-
prepared for working on a railway in Scotland, at a contemplat-
speed of 40 miles an hour. At the present time it was impossil
to keep the road in good repair, especially on the old lines,
consequence of the enormous weight of the engines.

ether it was anticipated that these small
lurable, and have as long a life-time as
ives.
, that he expected the small engine would
tive purposes, and even more so than an
ons; the bearings could be made larger
in, and the boiler being smaller in dia-
be compressed with greater safety. The
ked at 120 lbs. pressure, while in ordinary
d 80, and hence an advantage of 40 lbs.
ting surface of the fire-box was 25 feet.
said, they had a great number of small
e line, but they were not able to take the
was that in a long run the small engines
and were not able to keep up their steam
ke a load.
he had, with the Enfield engine, made the
had ever been performed between Norwich
a train capable of containing 84 passen-
the distance of 126 miles in 3 hours 35
toppages. Another advantage in a large
ption resulted from making use of the side
only 8 wheels to do the work of 24, and at
had no greater amount of weight on each
e ordinary arrangement. The whole weight
assengers, and 84 passengers might be taken
ghing 6 tons.
L said, that undoubtedly with the present
tion of the tare to the passengers carried was
ough a case which rarely happened, instances
the tare was 50 tons to 3 tons of passengers.
e weight of passengers at 10 tons, 50 tons of
stionably a large proportion of dead weight to
idered that the long carriage, if always likely
l, would be an advantageous mode of saving
ore especially on branch lines, and at the junc-
ranches came in.
N said, they were much indebted to Mr. Samuel

for bringing the subject before them; and he only wished tha
more of their railway friends had attended the meeting, for it wa
a paper which well merited their deep consideration in the presen
depressed state of railway interests. The question of economy i
the heavy current expenses of railways had for some time occupie
his attention; and although he did not go to the full extent wit
the proposer of this new system, he nevertheless went to a consi
derable extent with him, and admitted that there were cases o
passenger traffic, and branch traffic, and sometimes even shor
local lines, such as that from London to Greenwich, London t
Blackwall, or London to Broxbourne, where the number of shor
passengers was great, and the number left in long trains wa
very small, thus causing the train after a certain portion of th
journey to work very disadvantageously. He had no doubt tha
companies would have to classify these trains to a much greate
extent than had hitherto been done, and in that case the presen
plan might be tried with advantage; but he could not go wit
Mr. Samuel in saying that an engine so light as he had describe
was applicable to express travelling.

Even the principle of attaching a carriage to the engine fo
the purpose of giving adhesion, appeared to him a very doubtfu
expedient, because small engines were much heavier in proportio
to their power than large ones. He considered that Mr. Samuel'
arrangement in the case of the Cork and Bandon engine was
good one, but attaching a carriage to an engine was very objection
able; it was like riveting harness to a horse, and could not b
desirable under any circumstances whatever. Mr. Samuel did s
to increase the weight on his driving wheels, and consequentl
obtain more adhesion; but he forgot that he had already mor
weight on the driving wheels than was adequate to drag the car
riage along. This was adding more than enough, because a
engine that weighs only 5 tons is not so capable of slipping upo
the rail as an engine that weighs 30 tons, and therefore attachin
a carriage upon the frame of a small engine was superfluous, an
the inconvenience arising from having them riveted together woul
in some cases be exceedingly great, more especially in working
station.

Cases however might presently arise which would be favour

pment of the proposed system; for instance, aid down where hardly any justification existed on; these must be worked at the least possible uel's plan might be adopted advantageously; y useful system be overstrained, because there 1 line, express or otherwise, to which it could by cable. It would be largely applicable to minor ie (the chairman) felt that if he were to allow ead without saying anything, considering the occupied in the railway world, it would be uiescence on his part in the broad principle of gines where in fact for a period of nearly 20 831) they had been doing everything in an o that which Mr. Samuel was now pursuing. been contriving engines to develope railway n trunk lines, where not only great dispatch, is exacted; and he would ask whether the tisfied to be packed up like fish, ninety in a y would not be content with inferior accommo- ıtly evident from the eagerness with which on ion persons made their way to the four inside e thought were much more conducive to com- guage carriages with eight inside.

emarked, that in his carriages he thought there d better accommodation than afforded by the not only were they 9 feet wide, but high enough ngers to stand upright if they felt disposed.

N did not think that the loftiness of the car- objection, because it was quite possible for a losely packed.

replied, that he allowed the same floor area for in the present system.

nks was passed to Mr. Samuel for his paper.

; paper, by Mr. McConnell of Wolverton, was

ON RAILWAY AXLES.

vay system was first introduced into this country, the ngth of the materials for constructing the new stock

was (it is to be presumed) materially influenced, by the amount of exp rience derived from the vehicles which had previously been in use fo the conveyance of traffic.

As the new system became extended and improved in all its arrang ments, and the facilities which it possessed for conveying greater loa at higher speeds were gradually developed, the working stock was nece sarily changed from time to time in conformity with the greater deman for convenience and stability. Improvements in almost every poi have been carried out until we have now in operation the railway stoc generally speaking, in an excellent condition for the purpose to whi it is applied.

It is remarkable that, notwithstanding the importance of proportio and quality as first elements in considering the strength of the materia of which railway moving stock is composed, no rule, generally applicab for even the main features of this great system of machinery, has bee established.

Without attempting to embrace the whole subject, although one great importance to proprietors of railways and the public generally, conceive it is proper in this place to express my strong conviction th the general question of the strength and quality of those materials just proportioned to the strains to which they are subject, and bearing ref rence to accidents from collision, faults of road, deterioration from variety of causes, &c., must eventually be treated with great attentio and consideration; and in order to insure safety to life and property fo all who use railways, as well as the greatest possible economy for th profit of those who have embarked their capital in their construction, believe it will be found essential to have some regulations founded upo the joint experience of those parties who have been practically engage in managing and working the different departments of railways.

It is well known that short-sighted economy has been practised many instances in giving directions for the purchase and repair of ra way stock, and it is only dear-bought experience which can effectual convince those parties who, to make a little saving by purchasing cheap ill-constructed machine, gain a great and constant loss whilst it in use.

The advantages of a general and constant interchange of opinio among those parties to whose judgment and management the workin expenses of the different railways are entrusted is most important; an if such varied experience could be collected regularly and systematical into one focus, where it might be digested and prepared for practical us the effect for good to the general system of railways would be very grea

nt of view, the results recorded would prove

y stated a portion of my views as bearing upon best means of producing uniformity in the work- will now proceed to consider "Railway Axles," part of the great machinery, are deserving of

d to ascertain whether any data were available in forming a groundwork of the results of com- subject; but I regret to say that, although my ll cases promptly and carefully attended to, yet in view has not been attained.

the diversity of opinion, or rather perhaps the rule to guide engineers in proportioning the eir weights and strains, I would refer to the now in use on one portion of one railway, and in that a clearer proof could not be afforded of the efined principle to guide us in deciding on the es.

s I wish particularly to guard against expressing, any opinion on any description of manufacture of iron of which axles are composed. I would of the present paper simply to the question of s of axles, with the changes and deterioration to in process of working, assuming in all cases the xles are made, and the mode of manufacture, ved description.

at a knowledge of the best form and dimensions ascertain the load and friction to which they are econdly, to estimate as nearly as possible the ll be subject whilst in motion.

n or carriage to be constantly in a state of rest, n only be necessary to consider the axle as a ning a load of 5 tons upon the two journals, being the wheels resting upon the rails; the axle being of sufficient strength to sustain the erpendicular position. We then require to find strength, so that each section of this beam or fficiently strong to resist the strain or load to t.

by an approximate calculation, that a journal

1.128 inch diameter, is not capable of sustaining a heavier load when a state of rest than 2½ tons, or 5600 lbs.; and allowing in practice t the waggon or carriage axle is made ten times the breaking strength, t diameter of the journal would be, adopting the same calculation, 2. inches. In these calculations the strength alone is considered, but have also to take into account the question of friction and likewise t tendency to abrasion.

With our present means of information no accurate data are ava able for determining the best proportion of journal or bearing accordi to the weight it has to bear, or the velocity at which it is required move. A great variety of proportion is in use, but it is fair to note t in engine-axles particularly, the length of bearings depends to a cert extent upon the construction and arrangement of the engine; as general rule the length of the bearing is not in due proportion, acco ing to our general experience, to the diameter.

It has always been considered that having first ascertained, fr example and experience, the strength of sectional area necessary und under every circumstance to sustain the load which the journal has carry, the length of it was determined by the velocity or amount friction to which it is liable. Judging from axles at present in use carriages and waggons, the length of bearing is twice the diameter the journal; but on this, as well as other points on strength material, there exists a great variety of opinion. Even the forms journals are found to differ very much. Without attempting to deci on the merits of any of them, I shall in the present instance conte myself with stating, that all my experience has proved the desirablen of maintaining the rubbing or wearing surfaces of bearings as free possible from sharp abrupt corners, and sudden alterations in diame or sectional strength.

Having thus treated the journals as regards the load and the fr tion upon them, I now proceed to estimate the various strains to whi the axle is exposed whilst in motion.

The first strain to which the axle is subject is that arising from t weight of the waggon and load, which being received or resting on t journal produces the greatest effect upon the axle at the outer face the wheel-boss, and to which is to be added the momentum of the lo in falling through the spaces caused by inequalities in the joints of t rails.

The injurious consequences upon the axle of inequalities of t road surface, and flat places on the surface of the wheel-tyre, by t jolting or perpendicular motion which they produce, cannot be accurate

hese are very much increased when the bearing springs carriage are not sufficiently elastic, and do not yield low downwards, so as (to use the expression) to cushion n instance of the imperfect action of the springs, I hose in use on many waggons, in which the form and e them to be so rigid that the downward blow is more on an anvil. To obviate this strain as much as posry to proportion the spring so as to sustain the load to be of sufficient elasticity to absorb the effect of the

arising from the oscillation of the waggon on curves upling, and increased by the lateral freedom or space or play between the rails and flanges of the wheels; egularity occurs on the side of the rail, or any sudden direct motion of the waggon onwards, is in effect the on the flange of the wheel, the radius of the wheel lever to break the axle at the inner face of the boss

in the compound ratio of the momentum of the hich the wheel strikes the rail, and the distance from axle to the point of impact, producing an effective at the inner face of the wheel-boss, which extends the whole axle between the wheels. To lessen in possible the deteriorating effect of these descriptions xle, the following conditions are important:—

gs or journals of the axles fit as closely to the brasses freedom, the allowance of flange-guage of wheel t for the carriage to move freely round curves and rity in the guage of the rails.

s or carriages be as equally loaded as possible, and xactly in the centre; and as side chains are dane completely removed, provision being made for a chain should a failure take place. As the damage ons is in proportion to the oscillation, they should er by means of screw-couplings, having spring- of every waggon.

that the injury to the waggon, to the load which which carries it, and to the road over which it ravated if the waggons are allowed to oscillate become like so many battering rams, injuring stances in contact with them. A train of waggons

or carriages should be jointed together similar to the vertebræ of animal, by which means any sudden lateral action would be neutrali by the support derived from the neighbouring vehicles.

The road to be kept as accurate as possible to guage and line.

The third class of strains to which axles are liable are the sho produced by starting and stopping a train, and which are in propor to the momentum of the wheel and axle at the time of collision w stopping, and to the velocity of the impelling force and the inerti the wheel and axle when starting; these strains are felt principally the neck of the journal.

Fourth strain—the torsion or twisting caused by the wh travelling over curves of the line; the difference in length of face of the inner and outer rail compels one wheel to grind or s upon the rail, while the other is free to roll. This strain is portionate to the load on the wheel, determining the amount of fric upon the rails and the length of axle between the wheels; a sli amount of torsion is also caused by any variation in the diame of the wheels on the same axle, by any inequality upon each jour the quality of the brasses, or the amount of lubrication proportionat and the strain of the break block on one side, because when any of th occur separately or jointly, one-half of the extra strain on one jour is transmitted through the axle to the other, and twisting or weaken the axle is necessarily produced. To lessen the amount of the ab strain, it is obvious that the wheels should be kept in the best poss state of repair so far as equal diameters and true circular surfaces concerned, the waggons or carriages should be loaded equally on e side, the journals carefully lubricated, and all break blocks adjusted bear the same pressure on both wheels of the same axle.

Fifth strain—the constant vibration of the whole axle. This more particularly the case and is accelerated when the axle is fixed i rigid, unyielding wheel. My experience has proved that the axles fi in cast-iron wheels are very much more liable to deterioration than th in wrought-iron wheels, and the jar or vibration tending to deterior the quality of the iron, by altering its texture from fibrous to crystalli is clearly visible in its effects in several fractures which I have seen. would appear that the cast-iron wheel acted more like a hammer on axle, and as in the cold-swaging process, a gradual breaking up of fibre at the back of the wheel goes on, which is shown by an annu space, varying from ⅛ inch to ¼ inch in breadth; the strength is c pletely destroyed of this outer portion, and a sudden shock of the wh upon some point of the road completes the fracture of the axle.

ses which contribute to the deterioration of axles
practice of throwing cold water on the axle to
become nearly red hot from the want of proper
nal.

ie strain to which the portion of the axle between
there can be no doubt if the form of the axle is
ny blow transmitted through the wheel is received
le body of the axle, and the sectional strength at
alanced to resist the effect of the blow, the axle
d to prevent deterioration at any particular place.

determining the weakest point of a common wag-
ent circumstances, I made a few experiments, as

riment the power was applied to the flange of the
nce (as in the case of a railway axle when running)
pposite wheel; the result was that the axle began
it line at 12½ inches distance from the boss of that
wer was applied, and there is no doubt that if the
nued the fracture would have taken place within

is, in the second experiment, an axle of precisely
s and form, on being bent alternately backwards
wer being always applied on the same wheel at
broken at the twelfth time of bending, within 6
the wheel.

eriment the power and resistance were exactly in a
centre of the axle, and the result, as might be
of a nearly uniform radius, proving that although
was adapted to receive the blows of both wheels
instant, and to the same extent (an impossible
tice), it was not suited to receive alternate strains
ll axles are subject in ordinary use.

axles in the above three experiments were pre-

periment another axle of the same dimensions was
the centre in a lathe to the following dimensions:
led into eight equal spaces from the back of the
f the axle. Immediately at the back of the wheel
ies diameter, and the deflection was 9½ inches;
the diameter was 3⅞ inches, and the deflection
the second space the diameter $3\frac{3}{16}$ inches, and

deflection 7 inches; at the third space the diameter $3\frac{1}{16}$ inches, a
deflection $5\frac{5}{8}$ inches; at the fourth space the diameter $2\frac{15}{16}$ inch
and deflection $4\frac{1}{4}$ inches. Up to this point the axle maintained
straight form from the back of the wheel, and from this point to t
centre of the axle, as shown by the deflections, it assumed a fair cur
proving that the axle was weaker towards the centre than it ought
have been, and that the first 12 or 14 inches from the wheel, havi
maintained the straight form, was stronger in proportion.

In the fifth experiment the axle was reduced to two inches and
half in the centre, and, with the power applied as in the last case, t
weakness at the centre was more perceptible.

In the sixth experiment the axle was made of another form, weak
immediately at the back of the wheel and at the centre. We had he
two bends or curves, with a straight portion between them.

In the seventh, there was an improvement upon the sixth, but
did not realise a perfect balance of strength at the different points.

In the eighth experiment this was fairly accomplished, the propo
tion being as follows:—From the back of the wheel to the centre of t
axle the sizes were $4\frac{1}{16}$ diameter, $3\frac{1}{4}$ diameter, 3 inches diameter, 2
diameter, $2\frac{13}{16}$ diameter, $2\frac{3}{4}$ diameter, $2\frac{11}{16}$ diameter, $2\frac{11}{16}$ diamete
$2\frac{5}{8}$ diameter; the half-length of the axle being divided as before in
eight equal spaces.

It must be evident that this can only be an approximate result, b
we found that these proportions enabled us to attain the nearest approa
to a regular curve in bending the axle; and it is worthy of notice th
when the dimensions of the axle at the journal and in the boss of t
wheel are determined, a calculation to ascertain the exact proporti
between the wheels seems to confirm the above statement of dimensio
in the eighth experiment.

The greatest strain to which this portion of the axle is subject, bei
received at the bottom flange of the wheel, and transmitted through i
radius, the amount of strain which any portion of the axle has to resi
is inversely as its angular distance from the point of impact is to t
radius of the wheel.

Assuming the blow on the flange of the wheel to exert a breaki
force equal to 102,229 lbs., and the diameter of the axle to be 4.
inches to resist this blow, then, dividing the axle into four equal spac
to the centre, the proportionate breaking force at each point would be
follows:—At the first, 94,381 lbs., relative diameter, 4.59 inches;
the second, 80,697 lbs., relative diameter, 4.35 inches; at the thir
67,798 lbs., relative diameter, 4.11 inches; at the fourth, 58,899 lb
relative diameter, 3.92 inches.

rd to engine axles these proportions will apply where no
xist of employing the centre of the axle for transmission
e crank axles of locomotive engines cannot be treated by
es applicable to straight axles; and our experience would
that, even with the greatest care in manufacturing, these
ct to a rapid deterioration, owing to the vibration and jar
s with increased severity, on account of their peculiar
tain and regular is the fracture at the corner of the crank
e, that we can almost predict in some classes of engines
f miles that can be run before signs of fracture are visible;
unt of injury can be prevented by putting counter-balance
site to each crank, which lessens the vibration very con-

it to observe in this place, that to some extent the injury
ay be increased, if the wheels in which they are fixed are
alanced, and I have no doubt that a great portion of the
ation to which they are subject may be traced to the
on of the wheel upon the rail, owing to a want of balance.
stion of deterioration of axles arising from the various causes,
e enumerated, is a very important one to all railway com-
some change in the nature of the iron does take place is
hed fact, and the investigation of this is most deserving
ention.

e it will be found that the change from the fibrous to the
aracter is dependent upon a variety of circumstances. I
l a few specimens of fractured axles from different points,
establish the view I have stated. It is impossible to em-
present paper an exposition of all the facts on this branch of
but so valuable is the clear understanding of the nature of
ion of axles, that I am now registering each axle as it
e workshops, and will endeavour to have such returns of
ances and appearances at different periods as will enable
respecting their treatment. When it is considered that on
of Great Britain there are about 200,000 axles employed,
e of having the best proportions, the best qualities, and the
nt for such an important and vital element of the rolling
e universally acknowledged.

HAIRMAN observed, that as there were many members
versed in the qualities of iron, he hoped they should
observations from them tending to confirm or to call
the positions taken by Mr. McConnell in his paper

Mr. HENDERSON thought the subject was a very importan
one, and had been well treated in Mr. McConnell's paper; an
he hoped the investigation would be carried out by further experi
ments.

The CHAIRMAN said, that Mr. McConnell had expressed
strong opinion, that a change took place from a fibrous structur
in iron to a crystalline one during the time of its being in use
and it would be satisfactory if an instance could be pointed ou
where this change had occurred, owing to vibration or any othe
treatment, for he had not been able to satisfy himself from man
experiments that any such molecular change took place. Ham
mering a piece of hot iron till it is cold produced a hardnes
called crystalline; but the question for consideration was, sup
posing an iron axle were annealed by heating to a dull red hea
and being allowed to cool slowly, would the "texture" of that iro
undergo any alteration afterwards from the vibration of the railwa
or any piece of machinery they were in the habit of employing. H
had not been able to detect an instance of the kind; and i
giving evidence before the Iron Girder Bridge Commission, h
mentioned cases of vibration going on from year to year withou
any sensible change occurring in wrought or cast-iron. For in
stance, they had the Cornish engine beam with a strain of 50 lbs
per inch, working 8 or 10 strokes per minute for more than 2
years; and certainly if a molecular change was introduced by vi
bration, it ought to be by that continual concussion and vibratio
but none was perceived. Again, the connecting rod of a loco
motive was a piece of iron in a most perplexing situation, for on
having more to do and having the strain changed more frequentl
it was difficult to conceive; and yet he had known the connectin
rod of a locomotive engine to vibrate 8 times in a second fo
several years' regular work, making more than 200 million time
altogether, but the iron retained its fibrous structure; and h
thought axles could not be subject to so much vibration. When
therefore, he found that a connecting rod did not change its mole
cular texture, he must say there were good grounds for doubtin
that iron changes its state in axles.

Then with regard to the experiments made by Mr. McConnel
with a view to ascertain where axles were most exposed to tension

e agree with him, for he subjected the wheels slow steadily increasing pressure, till he bent ent positions. The results were correct as far slow pressure on the flanches of the wheel nstances of the experiments recorded by him, ot a faithful representation of what takes place it would be found that when the wheels of a a violent blow was inflicted on the rail, and the e was totally distinct from a slow pressure.

efer to the experiments made some years ago by , on the Hull and Selby Railway, and which in the Engineers' and Architects' Journal, or the azine, to show how important is the element of cture of an axle. He took a round bar of iron l 2 inches diameter, and turned it down in the h in diameter for 2 inches in length. He then ar 1 inch in diameter uniformly throughout, and ngth of these bars under *concussion* and not mere the severest point of strain would evidently be the ars where the diameter was the same in both, and weights were gradually and quietly laid on, the alike in both bars; but when small weights were the bar 1 inch in diameter throughout its whole d to be much stronger than that which was in the nd 1 in the middle. For as time is an element nce of material is concerned, regarding the axle as ce of india-rubber, the only particles that could on from the falling weight were those between the part of the axle that was turned down, but in bar an inch in diameter throughout its whole e of the particles would yield; the one being a l the other a very bad one.

e appeared to him that the experiments recorded nell, though correct as regarded the position in em, were not correct as regarded concussion. The ever broke in the middle, but generally at the end s of the wheel; because of the sudden change in f the axle at that point; the portion of the axle

fixed within the boss of the wheel being very rigid whilst the rest remained elastic, which caused the vibrations to be suddenly checked at that point. No doubt the plan of weakening axles in the middle had done good because it made them spring, and in crank axles it relieved the strain in the cranked part.

Mr. Henry Smith suggested that in the case of bar-iron, the exterior portion had greater tenacity than the interior or under part; and the strength would be more than proportionately diminished where the exterior portion was cut through. He also referred to some experiments in which he had cold-hammered fibrous iron till it became crystalline, and the effect produced corresponded with the description given by Mr. McConnell of the fractured axles.

Mr. McConnell observed, that he had met with several cases of broken axles in which a distinct annular space was observable all round the surface of fracture, that was quite short-grained and appeared changed into a crystalline texture, whilst the centre of the axle remained fibrous. He admitted that his experiments were only approximate, and that he had not put the strain in the natural way; but it was almost impossible to do so in consequence of the great trouble and expense that would have accompanied it; at the same time the results were proportionate in each case, and the accuracy of the experimental results had been confirmed by calculation. With regard to the axle fitting into the wheel, they now allowed only a very small shoulder, not exceeding a sixteenth of an inch, and this shoulder was not square but tapered, and the boss of the wheel was slightly coned to fit the shoulder.

Mr. Cowper did not believe that any axle which when broken proved to be crystalline had ever been fibrous in its character.

Mr. Ramsbottom considered that a change took place in the axle from the effect of mere mechanical action, and his observations had tended to confirm him in that opinion. Some time ago he selected an axle which had not a very good form of journal, and the end broke off with two blows of a 12 lb. hammer. This axle had for three years been subject to a strain vertically, which was reversed at every revolution, and it came off with a crystalline

n tried the part that had been within the boss
h had not been subject to this great strain, and
n was very much greater than that of the jour-
ed 79 blows to break it off, and in that case the
us. A parallel case might be observed with
sh stick which if doubled would break with a
but if subjected to vibration, however slight,
it a great number of times, it would break in a
He thought the strain on a locomotive connect-
o means so great for the sectional area as upon
and the latter had two reversed strains for every
small wheels, but the connecting rod had only
ution of the driving wheels.

IAN said, he was only desirous to put the
r guard against being satisfied with less than
ence as to a molecular change in iron, for the
of serious importance, and the breaking of an
occasion rendered it questionable whether or
and superintendent would have had a verdict
eturned against them. The investigation hence
test caution; and in the present case there was
how that the axle was fibrous beforehand, but
it broke. He therefore wished the members of
onnected as they were with the manufacture of
ore they arrived at the conclusion that iron is a
o crystallize or to a molecular change from vibra-
n part, he was now induced to look upon wrought-
astic, like a piece of india-rubber; for in the case
ubular Bridge, where they had two 10 inch square
ch 100 feet in length, it was found that before
ed the chains or bars stretched nearly 2 inches in
me of lifting, but resumed their original length
was withdrawn; the same action being repeated
ube was lifted. He could therefore only regard
s of iron as analagous to a piece of india-rubber.

NELL said, he had one specimen of an axle which
shed nearly incontestible evidence of the truth of
t a change took place in the texture of the iron.

One portion of this axle was clearly fibrous iron, but the oth end broke off as short as glass. The axle was taken and ham mered under a steam hammer, then heated again and allowed cool, after which they had to cut it nearly half through and hammer it a long time before they could break it.

The CHAIRMAN remarked, that this was a case of conver reasoning; for it was an instance of a piece of crystalline iro being converted into fibrous iron. Iron when it was once heat and allowed to cool gradually, acquired a close and fine grain, b became neither crystalline nor fibrous; if cooled suddenly acquired a crystalline grain, and if rolled while being cooled became fibrous, but he did not think that it underwent any mol cular change from mechanical action after it was cold.

Mr. HENRY SMITH observed, that throwing cold water upo hot journals did great injury by crystallizing that portion of t axle.

Mr. SLATE did not think that any change from a fibrous to crystalline texture was produced in iron unless it were straine beyond the limit of its elasticity. Some of the pump rods Staffordshire which had been in use for 18 or 20 years, were su ject to a strain of 3½ tons per square inch; and a short time a he had occasion to ascertain their actual performance with referen to this very question, and this not being considered conclusive, h had made a machine in which he put an inch square bar subjecte to a constant strain of 5 tons, and an additional varying strain 2½ tons, alternately raised and lowered by an eccentric 80 or 9 times per minute, and this motion was continued for so long time that he considered it equal to the effect of 90 years' railwa working, but no change whatever was perceptible; and therefo he was one of those who did not believe in a change from a fibrou to a crystalline structure in iron. He remembered a case whe a question having arisen as to the manufacturers of a certai shaft, it was agreed to hammer it until it split as a means of di covering the nature of the manufacture of the shaft; the resu was satisfactory; and the iron appeared still fibrous in texture.

Mr. HENRY SMITH promised to furnish some results of col hammering iron, at the next meeting.

The further consideration of the paper was then adjourne and the Chairman said he wished that more of the Members ha

he meeting, and hoped they would attend and
ler discussion of the subject.

anks was passed to Mr. McConnell for his com-

g paper by Mr. Sampson Lloyd of Wednesbury,

NASMYTH'S PATENT GIRDERS AND FIRE-PROOF FLOORS.

n or peculiar construction of Girders, Fire-proof &c., which is the subject of the present paper, mainly ıptation of the "Bow and String" principle to the uired; and the method adopted in the construction of lained by the accompanying Drawings and Models.

ENTION AS APPLIED TO FIRE-PROOF FLOORS FOR BUILDINGS.

probable weight that the floor will be required to bear plate iron is taken of the required size and strength, form shown in Fig. 1 for the arch; and another plate nderside, which is turned up at each end as at A A, he space left between the turned up ends is of such a the upper plate in its bent form. This bottom plate be of the width of the top plate, unless an even sur strip of bar-iron or steel of the required strength will se; neither is it requisite to have the top plate of the be bent as in Figs. 3 and 4 if desirable. When the and placed within the turned up ends of the bottom for fixing between the Wall Beams or Girders as in pace B B is then filled up with concrete or other sub-ed as required. In all cases the under plate or tension cure perfect safety, be of double the strength that is quisite.

will be in proportion to the weight to be placed on turned up ends act as the abutments of the upper plate with its tension bars or plate becomes perfectly d has not the slightest lateral pressure on the Beams ch it rests.

reight which may ever be on such floor will act on the Firders by a crushing force, which is the most favour-y free from any lateral action, so long as the tension st, see Fig. 6.

her great advantage in this construction, the bays or

spaces between the Walls or Girders may be wider than when bri arches are used and of less thickness; and further, if from any unforese cause one or more of the plates of the flooring were to give way, other damage takes place to any other part of the floor, each plate bei quite independent and in no other way bound to either Walls or Girde

2.—The Application to Girders.

Girders in the first place may be considered simply as a Bow a String of the required lengths; on the Bow a second Arch is plac exactly corresponding with the outside of the Bow and extending to t point A A, see Fig. 8, having side plates B B, as also shown in Fig. This forms a complete case over the Bow, and when the Girder weighted, the arch being restrained from flattening or altering its sha by the case, the entire weight comes as a direct strain on the Tensi Bar or String C C, Fig. 8. There is no fixture or attachment to t Tension Bar except at the ends, and the internal Bow or String is p fectly free from the case, as shown in the models.

Supposing a weight were suspended from the string of a Bow, t effect would be to raise the Bow as shown in Fig, 9; whereas if t same weight was applied to the Case covering the Bow as in Fig. 1 the effect would be to spread the strain in the most uniform manner over the Bow, and transmit the whole weight into the chord or tensi bar. For example: If a Girder 20 feet long had 20 tons placed on t centre, on this principle each foot of the Girder would bear one ton, a the Tension Bar would have to sustain 20 tons. In bridges as p viously constructed it is customary to connect the Arch to the string in Fig. 11, and there must be a tendency to deflect between every co necting plate. The same effect is produced where the Girders a formed by applying the pressure over the top of the Arch, Fig. 1 there is no uniform pressure or tension, whereas on this principle t weight can either be placed on the arch or suspended as in Fig. 1 which represents a Bridge and roadway; and in every case, if the lo be placed in any varying position, the pressure and tension will uniform. The rise of the Arch from the Chord has hitherto been ma equal to one inch to the foot in length, and the Arch constructed placing plates of cast or wrought-iron between angle-iron as in Fig. 1 but there are other methods as circumstances may require.

When the string or tension bars are too long for one plate it proposed to use a series of links, such as are used in suspension bridge and from the great length such chains can be formed there does n appear any precise limit to the span to which Girders or Bridges may b carried. The chains themselves can be used as an element of increase

aying them on each side of the roadway, which being m the case covering the arch will be found to have the g rigidity.

dways in Bridges are formed of a series of Cross Girders, and between them arched plates are laid as in floors, and with ballast as required. For Bridges on this principle t be required abutments of any kind, all the weight being

or Girders can be constructed of very great span, as the ion is the same; and to prevent the tendency to sag in the light supports are easily placed under them attached to the as most convenient.

arehouses and large rooms where a clear space may be of the advantage of this construction of Girder will be felt ng manner, there being no outward thrust on the walls, consequently be built thinner than is usual, and there is no r stay bolts.

s can be made to sustain any given weight quite independent n, and with a peculiar advantage, viz., if a Girder was stain 20 tons, the same Girder can be made to sustain 40 t making it one inch deeper; as to attain this object it is only increase the width of the case and insert one or two additi-s and tension bars as may be required, thus only making the r, which in buildings is often of great importance, see Fig. 16.

3.—The Application to Roofs.

the patent construction is applied to Roofing the extreme ll be the chief feature. The bow and tension bar form the nd plate iron, timber, or any other suitable material is or covering the saddle or archcase, see Fig. 19.

4.—The Application to Bridges.

nvention is peculiarly adapted for Bridges, as previously there are many advantages not mentioned, one or two of be alluded to. When the foundations on which the pier of t are bad, the freedom from lateral pressure is of great im-lso in Viaducts where simple pillars or piers are built. In vide spans the outside Girder can be made of sufficient depth the arch of the Girder and case serve for the parapet, see

5.—Dock Gates and Caissons.

rinciple is applicable to the construction of Dock Gates and particularly to such as are of large dimensions. In such con-

structions the tension bar may be in the centre with an arch and case on each side as in Fig. 17, capable of resisting equally the weight of water on either side.

6.—Jetties or Piers.

Jetties or Piers may be advantageously constructed on this principle, and may be made to extend a considerable distance for a comparatively small cost. For instance, a Foot Bridge or Pier as in Fig. 18, may be constructed to rest on the land in the usual way on the one end, and on a barge at the other, rising and falling with the water.

In conclusion, it may be observed the advantages attained by this invention are, that in *Fire-proof Buildings* the walls are free from lateral thrust; the floors may be made thinner, and the number of stories safely increased; rooms of a large size may be constructed without any pillars or supports except the outer walls, at a much less cost than in the ordinary construction. Floors on this construction are fire-proof, are easily made to sustain any given weight or to support an increased weight, and are not liable to be destroyed by decay or vermin, and no part of the floor giving way causes an extra strain on the other parts, as the whole floor is formed of self-contained and independent parts.

In *Girders*, by the combination of wrought-iron, cast-iron, and steel their strength, form, or weight may be adapted to meet almost all circumstances; and larger spans in *Bridges*, &c., can be adopted with a much less consumption of materials than in other constructions, besides taking into consideration the slight support required from the absence of lateral thrust.

Many experiments have been made on a larger scale than the models now laid before the meeting; and it has been ascertained that the comparative strength of these Girders, when compared with cast-iron is as 7 to 28, or four times as strong: that is, a girder that would weigh 4 tons in cast-iron, to carry a certain weight, can be constructed to carry the same weight on this principle and will only weigh 1 ton.

Mr. Lloyd regretted that Mr. Nasmyth was not present, as he would have been much better prepared to explain the principle of the girder, and answer any objections that might be raised. Mr. Nasmyth had intended to be present at the meeting, but was unexpectedly prevented from attending.

The Chairman observed, that the bar of wrought-iron which was employed as an arch in the girder, was not capable of sustaining much compression without buckling; and he could not understand why wrought-iron was introduced into arches, when the arch was the best possible form for the adoption of cast-iron.

plied, that though cast-iron would bear a
, the introduction of wrought-iron facilitated
he pressure over the whole girder. The longi-
as placed over the arched rib distributed the
ib, and prevented it from buckling, and the
onveyed to the tension bar.

thought the proposed construction involved the
arge quantity of metal which was of no possible
rly the metal in the ends of the box of the
not appear to give any addition to the strength.
d to know the results of experiments on the
gth of the girder; and he much doubted the
e plan to girder bridges. He suggested that it
make the wrought-iron box in the form of an
the place of the arched rib, which he considered
ne strength with much less material.

AN remarked, that he did not see where the
ow and string girder, differed from that of the
cted on the North Western Railway at Camden
r.

SON thought the principle was the same only
iron instead of cast-iron for the arched rib, and
much preferable for the purpose; he believed
f wrought-iron had been caused by the public
reference to cast-iron girders of large span.
m that the plan proposed for distributing the
girder, by covering it with a wrought-iron box,
both in theory and practice, and involved a
; and he considered the most economical and
doing it was by the introduction of diagonal
n the arched rib and the tie, instead of con-
s.

AN agreed with the suggestion of Mr. Cowper
preferable to combine together the box and the
of putting the material in the form of an arch,
ld be better to carry it straight along the top.
was entirely subjected to compression and the
ension, and when the parallel form was adopted
and tension acted by the same leverage at all

parts of the girder; but when thrown into the arch form this leverage was so much diminished towards the ends, on account of diminished depth of the girder, that the thickness would require increasing there to obtain sufficient resistance, which involved an increase in the quantity of material employed.

Mr. COWPER thought this increase would be slight, compared with the saving of material effected at the ends by adopting the arched form instead of the straight top. In the parallel box-girder, formed with side-plates, the strain passed down obliquely through the side-plates to the lower part of the girder at each end, and the plates were required to be thicker at that part; but he thought the better plan was to place the material in the direction of this strain by making the box-girder in the form of an arch, and tying the ends together by the tension bars.

Mr. SLATE was of opinion, that a cast-iron rib with a wrought-iron tie, was the most economical and efficacious application for the girders of railway bridges.

The CHAIRMAN remarked, that with some variation the proposed plan might be satisfactorily adopted for supporting the floors of warehouses, but he thought there would be great difficulties in applying it to bridges of large span.

A vote of thanks was then passed to Mr. Lloyd for his communication.

The CHAIRMAN announced that the Ballot lists had been opened by the Committee appointed for the purpose, and that the following new Members were elected.

MEMBERS.

Mr. Humphrey Chamberlain, Worcester,
Mr. William Johnson, Glasgow,
Mr. Robert Morrison, Newcastle-on-Tyne.

A vote of thanks was passed to the Chairman, and the proceedings terminated.

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PROCEEDINGS.

JANUARY 23, 1850.

D ANNUAL MEETING of the Members was held at
otel, Railway Station, Birmingham, on Wednesday
nuary, 1850; J. E. MCCONNELL, Esq., V.P., in

RMAN in opening the business of the meeting, re-
e was called upon to preside in consequence of the
sence of their President, Robert Stephenson, Esq.,
oidably detained at Liverpool, and had expressed
lisappointed that he was prevented from attending

tes of the last General Meeting having been read
ry, were confirmed.

RMAN said he was very glad to be able to congra-
bers on the continued prosperity and the increasing
Institution, which now comprised more than two
bers; and he proceeded to read the Annual Report
upon the proceedings of the last year.

(See "Report," &c., appended.)

MITH moved that the Report be adopted, and the
conded by Mr. Richards, and passed.

RMAN then stated that there was one subject that he
which had been considered by the Council, and
pinion that this was the proper time for bringing it
nbers of the Institution. It would be recollected
ter the decease of their late lamented President,
nson, a brief memoir of his life, prepared by Mr.
had been read at the Institution; and some allusion
e to a more permanent expression of their respect
y. The Council thought that the time had arrived
ution, in which he had taken so active an interest
ent, to take the initiative in the proposal to do
memory of their esteemed friend, by the erection

of a suitable monument in an appropriate position; and they confident that the proposal had only to be named, to meet w hearty response and cordial coöperation from every one acquai with the distinguished merits and genius of one who had don much service to his country and so much honour to his profes

Mr. GEACH rose to propose a resolution in accordance the remarks of the Chairman, and expressed his conviction the public mind was quite prepared for such a step, and there were numerous admirers of their late President who w gladly coöperate in the object. It was not for the Council o Institution to decide in what precise form the memorial shoul carried out, they merely proposed to take the initiative in matter, and the Council would take steps to get a larger and r comprehensive Committee than their Institution would furnis consider the best means of marking in a lasting manner the opinion entertained of the moral worth and scientific charact the late George Stephenson.

He proposed the following resolution :—"That it is opinion of this Meeting that the time is now arr when some steps should be taken to commemorate memory of the late George Stephenson, and tha this Institution was founded under his auspices, during his life he continued its President, the Mem can appropriately claim the privilege of originatin appeal to those willing to coöperate for the above pose; and that the members of the Council be appoi a Committee to carry out the above object."

Mr. BUCKLE seconded the resolution, and it was passed.

The CHAIRMAN said that the ballot lists had been opene the Committee appointed for the purpose, and they reported the following Officers and Members of Council were elected the ensuing year.

PRESIDENT.

ROBERT STEPHENSON, M.P., London.

VICE-PRESIDENTS.

CHARLES BEYER, Manchester,
J. E. MCCONNELL, Wolverton,
JOHN PENN, London.

COUNCIL.

Villiam Buckle, Birmingham,
. E. Clift, Birmingham,
. Scott Russell, London,
Robert Sinclair, Glasgow.
oseph Whitworth, Manchester.
e ten Members of Council who continue in office from
)

TREASURER.

Charles Geach, Birmingham.

SECRETARY.

Villiam P. Marshall, Birmingham.

man announced that the following new Members
l.

MEMBERS.

Matthew Curtis, Manchester,
Robert B. Dockray, London,
onathan Dickson Ikin, Westminster,
ohn Linn, Barrow-on-Humber,
. S. Norris, Warrington,
ndrew Shanks, Johnstone,
Thomas Thorneycroft, Wolverhampton.

HONORARY MEMBERS.

Villiam Lucy, Birmingham,
Edward Watkin, London.

Smith proposed a vote of thanks to the Council
s, which had been productive of so much benefit
n. The resolution was seconded by Mr. Crosland,

---

ed discussion on Railway Axles was then intro-
the following additional paper by Mr. McConnell,

ERIORATION OF RAILWAY AXLES, &c.

n requested at the last meeting to furnish further
ge from the fibrous to the crystalline character pro-
Axles, and feeling convinced that a strict and care-
f this important subject is a *necessity* in this age of
the enquiry has been resumed in the hope that the
on and experience gained may tend to a more per-
the subject.

Before stating the results of the different experiments which h
been made with the view of ascertaining the cause and extent of
change from the fibrous to the crystalline appearance in railway A
iron, it must be observed that in this, as in some other matter
controversy, it is most difficult to produce full and conclusive p
that the iron which is produced of a crystalline character was
fibrous, as we cannot by any experiment show the change vis
taking place; but surely it is fair and reasonable to admit the
of a change, when we find Railway Axles when new, from
particular mode of manufacture, present through every part of t
substance a tough, strong, fibrous appearance, yet after several y
use, we find axles of the same description, owing to the var
deteriorating causes in action, break short at the back of the w
and then present an appearance totally different from the orig
structure of the iron, as described above.

It has so happened, in strong confirmation of the views state
the writer at the former meeting, that a very remarkable instanc
this change was brought under his notice shortly after that discuss
and he thought the evidence which this case furnishes so impor
and conclusive, (although produced without any design, and in
nary course of business) that the axle has been brought for the
spection of the present meeting.

This axle was fixed in cast-iron wheels, of the pattern in us
several lines of railway, having the H form of spoke, and as
wheel is perfectly rigid, experience has proved that the axles are m
more liable to deterioration when working in these kind of wh
than in those wheels made partly of wood or other constructio
wrought-iron, &c., which may have a certain amount of elasticity.

The axle now under consideration broke in ordinary wor
close at the back of the wheel as is usually found, and the fract
ends which are now produced to the meeting afford the most dis
proof of the annular space, which was stated on the former occasio
be observable all round the surface of the fracture; and this is
only short grained and crystalline, but there is also in the wr
opinion an evident distinct separation to the extent of the ann
space which it would appear takes place some time before the
fracture, as if each successive blow, heavy or light, lateral or ver
received or transmitted through the wheels, had each tended to
troy its proportion of cohesion of the previously crystallized subst
of the axle at that particular place where the fracture occurs.

On receiving this axle in the workshops, with one wheel
attached, it was allowed by accident to fall a short distance from

nd, and so brittle had it become next the wheel that
ɔed off simply from the effect of the fall, and shows,
ɛd, a precisely similar appearance to the original

s anxious to ascertain how far the theory which he
ıat the deterioration of the axle was principally local
ack of the wheel), and for this purpose he caused the
between the two fractures to be laid on supports,
reaking it. A weight of cast-iron weighing 17 cwt.
to fall upon it through a space of 14 feet, but after
was found to make no impression upon this centre
wards effecting a fracture, although it was a frosty
of course render the iron more brittle. Finding all
y blows fruitless, the axle was then, in order to test
r, taken to the hydraulic press, and it has been bent
letter U, until the two ends met, without showing
htest appearance of the skin of its surface breaking,
roving still to be of a strong fibrous iron in the
. See Fig. 1, Plate 1.

his proposition, the writer wishes to lay considerable
ıe previously stated, respecting the effect of the blows
given through the wheels to the axle; he attributes
of the axle at that point close behind the wheel, to
ge or reaction of the vibratory wave at that place,
k which it meets from the mass of matter consisting
presenting a break of surface, and acting more as
ıe vibration to react like a blow on the neck of the axle
est point), thereby destroying its fibrous character.

eels therefore are objectionable from their rigidity
n of the lateral and vertical concussion with other
numerated, received in course of working, and trans-
ly expended on the axle; and the writer endeavoured
y a comparative experiment with two different axles
iption and age, one being fixed in cast-iron, and the
vheels, those known as the Pimlico make.

ent was made on the axle with wooden wheels placed
g upon the rails; a weight of 17 cwt. was allowed to
tance of 13 feet 3 inches upon the axle, immediately
, by which the axle was slightly bent at the point
me, and a portion of the tyre resting on the rail was
This experiment was repeated four times on the
axle, which was bent but very slightly, and the
ed completely useless.

2nd Experiment was made upon the axle with cast-iron wheel placed as in the former case, and the same weight was allowed to fal the same distance at the back of the wheel, when the effect of the firs blow was to break the axle at the other end, at the back of the wheel thus proving that in the former case the axle was saved from fractur by the wooden wheel absorbing its full share of the effect of the blow and the tyre of the wheel breaking proved that in course of workin it would receive a portion of the deteriorating forces tending t crystallize, the wheel acting like a oushion to soften the blows befor they reached the axle; in the later case the rail supporting the cast iron wheel was fractured in three places.

A 3rd Experiment was tried with another axle with cast-iron wheel placed as before, and received four blows on each end of the axle withi the wheels, which caused it to bend, but produced no fracture. Thi axle had not been much used, and was of a stronger fibrous character

In order to ascertain the relative appearances of axles which ha been in use, and determine the position of the crystalline change, bot at the centre and outer surface of the axle, the writer caused four axle which had been condemned as too small from wear in the bearings, t have a groove cut in two cases on each side, to within an inch of th centre, and in the other two, grooved through to within an inch of th outer surface; these were split asunder with wedges, and their appear ances will show that a certain change has been going on, and this i more observable in one end of the axle than the other, attributable, h believes, to the break being applied to the wheel which was on the en where the greatest crystalline change is visible. See Fig. 2, Plate 1.

He has made a number of other experiments in the presence o several of the members of the Institution, with the view of deter mining the effect produced on the fibre of iron by the cold-hammerin process. The following are the principal results:—

No. 1. A piece of ordinary bar-iron $2\frac{1}{2}$ inches wide and $1\frac{1}{8}$ inc thick, received 20 blows to nick it across, and was broken with 2 blows of a 14 lb. hammer, showing a fracture part fibrous and par crystalline.

No. 2. The same bar received 52 blows on one side, and 55 o the other, from the 14 lb. hammer, with 20 to nick it as before, an it broke with 14 blows, showing different layers of fibre and crystal.

No. 3. The same bar received 50 similar blows on each side a No. 2 but each blow on alternate sides successively, and 20 i nicking, and 9 blows broke it.

No. 4. The same bar was not cold-hammered, but received 20 blow in nicking and required 28 blows to break it, showing a good fractur

$\frac{7}{8}$ inch square bar, received 50 blows on each of and 25 on each of the other sides, with 4 blows in ke it.

ut any cold hammering and the same bar, after to nick, required 6 to break it.

ame as in the case of No. 6, had no cold hammering, ck it, and required 30 blows to break; in this case flat way of the pile of the iron, but in No. 6 it was ay of the pile.

iment was made on a shaft $3\frac{5}{8}$ inches diameter, which d at one end, having received 204 blows on all sides hammer; 110 blows with a sledge hammer were end all round which had been cold-hammered, and blows from the $3\frac{1}{4}$ ton hammer to break it; the had not been cold-hammered, after receiving the lows in nicking, required 78 blows under the $3\frac{1}{4}$ ton it, thus proving the enormous amount of deteriorath of the iron caused by the cold-hammering process.

ce of round iron $2\frac{3}{8}$ inches diameter which had two ne at each end) $1\frac{7}{8}$ inch diameter by $2\frac{1}{2}$ inches long, n at a considerable velocity for about an hour, with the other dry, the dry end being cooled with water t became hot; the iron was then experimented upon ine by the different force required to break the end njured by want of lubrication, the relative strength out such was the remarkably tough quality of this h it received 520 blows of a heavy sledge hammer in to break it in one direction (without being nicked), l be effected, but the iron seemed to be drawing the journal on end, as will be seen by the meeting. is noticed in particular, as the following experiment cter with an old axle of larger dimensions, shows in e altered nature of similar iron from use on a railway, or vibrating action it has suffered.

xperiment a piece of new iron intended for part of run dry and cooled with water, yet was so fibrous, o jar, that it resisted all effort to break it.

other experiment of a similar character was tried on h had been a long time in use, of the same kind of cture as the bar in No. 9 experiment. This axle n was run in its own bearings in a lathe at a velocity s per hour for 5 hours; one journal was kept running

dry, and when heated by the friction cooled with water, while t other journal was kept well lubricated with oil. When taken ou the journal which had been heated was broken with 12 blows of hammer 22 lbs. in weight, while the lubricated journal required blows with the same hammer to break it, in both cases without bei nicked; this appears satisfactorily to prove the injury to the axle whi results from the practice of throwing cold water on the journal to cool when it has become nearly red hot from the want of proper lubricatio

In addition to various other experiments with the view of dete mining the change which is gradually going on in Railway Axles, a other iron liable to a jarring, vibrating motion, the writer would ref the meeting to a few of the samples of broken axles sent to him fro various quarters, which, if proof were wanting, completely substantia in his opinion, the certainty of the crystalline change.

Before reading some of the communications received from oth gentlemen containing their experience on the subject, he would fir call attention to the two experiments which were tried in relation the proportion and form of axle, in order to meet the objection rais at the former meeting, "that the slow pressure on the flanches of t wheel to discover where the axles were most exposed to the bendi strain was not a faithful representation of what takes place in practic The axle was fixed upright so that the wheels were placed in such position that the violent blow when the wheels of the carriage jarr upon the rail was fairly represented by the blow caused by the desce of a weight of 17 cwt. which was allowed to fall upon the edge of wheel at A. from a height of 9½ feet. It is most satisfactory to fi that the curve into which the axle was bent is quite in accordan with the former results, which were obtained by slow pressure appli at the same points, and establishes the rule of proportion of the ax therein stated. See Plate 2.

The following are some instances of tough fibrous wrought-ir being rendered brittle and breaking off quite square with a clos grained fracture from the effect of the concussion of very small blo rapidly repeated for a long period; the blows being very small in for compared to the strength of the iron. These specimens are from t machines for making button shanks, in Mr. Heaton's Mills, Birmin ham. The hammer in these machines is about 2½ lbs. weight, and lifted by a rod ⅜ inch square, which has a pull upon it of about 12 l from the difference of leverage; the hammer strikes 120 blows p minute, but the cam that drives it acts only during one-fourth of i revolution, so that the velocity of the hammer is equal to four tim the number of blows, or nearly 1000 changes of motion per minut The lifting rods always break with a close-grained short fractur

f the toughest and most fibrous iron that can be
y sometimes last only a few months; the rods break
which is fixed with a coupling, and the deterioration
rs to be confined within a small portion, the iron re-
ugh and fibrous within an inch of the fracture, as
cimen, which has been bent double at that part. The
ed suddenly by the lifting-rod, and is pulled against
r the purpose of getting a quick recoil and a sharp
ner much quicker than it would fall by gravity.
cimen from the same machines is the lever for push-
from the machine when stamped; the lever is about
de of the toughest wrought-iron, it is 9 inches long,
inst a stop at one-third of its length from the centre
bottom, being thrown back sharply by a spring, the
the lever varying from about 1 lb. to about 12 lbs.,
ccidental circumstances in the working of the machine.
reak off quite short and close-grained within an inch
trikes against the stop, but the iron continues quite
nged to within an inch of the point of fracture, as
cimen. They were driven at the same speed as men-
unting to nearly the velocity of 1000 changes of motion
they broke so frequently, lasting sometimes only a
t was determined at last to reduce the speed of the
20 to about 100 blows per minute, and in consequence
in speed the levers are much less frequently broken,
verage about four times as long as before.

tion from Mr. JOHN KEKWICK.

"*The Holmes, Rotherham, 4th December*, 1849.

n reading in the Mechanics' Magazine for last month
able paper on Railway Axles, and I notice Mr. Robert
that Mr. McConnell had expressed a strong opinion
k place from a *fibrous* structure to a *crystalline* one
of its being in use, and it would be satisfactory if an
pointed out where this change had occurred owing
her treatment, &c., &c.
can furnish an instance in proof of your opinion on

our Forges we are daily in the habit of using a metal
er weighing about 4 tons, for the purpose of drawing
l, and the shaft of this helve is 17 inches by 9 inches.
convenience and danger from the breakage of *cast*-iron

Helves, we were induced to try a *wrought*-iron one 16 inches b inches. After using this for several months the shaft broke in about the middle, and the fracture presented the crystalline appear of 'short' cast-iron: we repaired the shaft, and in the course of a months it again broke about the same place, and it again present similar granulated, cast-iron like, crystalline appearance throughout face of the fracture. I attributed this change solely to the *vibra* and *jar* occasioned in the process of hammering steel, more particul *cast* steel."

Communication from Mr. BENJAMIN GIBBONS.

"*Shut End House, near Dudley*, 15*th January*, 18

"When the heavy Cast-Iron Helves were used for drawing Bars, and the art of *chilling* iron was little understood, the nose or part of the iron Helve struck by the Cam to lift it was protected wrought-iron plate well fitted, and this was secured by a large countersunk into it, and extended through a hole cast through the of the Helve and screwed as fast as possible on the upper side. very best and *most fibrous* iron (ascertained to be so by previous br ing) was always selected, and yet when the pin broke by the repea shocks it had to sustain (about 90 times per minute), it always br with a large bright grain, *without the least trace of fibre*. This wa regularly the case that I never knew a pin last for many months.

"Another instance was in a Fly Wheel where Wrought-Iron A were used instead of Cast-Iron, for the purpose of throwing the wei to the outer circumference, and this wheel was applied to a Fo Hammer Engine. It worked well for a time till the arms got lo in the cast-iron rim, and then a violent shock was received every t the Cam struck the Helve; after some time the arms began to br one after the other, and though the iron was of the toughest descript originally, it was found that any part broken was of a bright crys line grain.

"The pins of Shears for cutting down large cold bars sust violent shocks; they perpetually break with the same bright gr though made of the toughest iron. Also the Iron Arms of comm carts always break with that grain from the same apparent cause.

"I have taken iron of this bright crystalline character which I previously known to be fibrous, and by drawing it down a little proper heat have never failed to restore the fibrous texture of the ir

The practical suggestions derivable from the foregoing exp ments and enquiries, which are confirmed by all the writer's prev experience and information, are—

axles of all Railway Engines, Carriages, and Vehicles the best ascertained quality of iron for the purpose, ong, and of uniform clean fibrous texture.

ortion of an axle in all its parts to be determined from nd calculation; the load it has to carry, the speed at d the description of wheel in which it is placed, and s liable in working from curves or inequalities of the riorating causes, being fully considered.

vious to any axle being allowed to run on any line, should be legibly marked thereon and the date of also when it was first put to work. It is of course icable to record the number of miles run, but as all a general way is worked nearly uniform, the above fford the necessary data to guide the opinion which the age beyond which limit the iron becomes com-

e part of the duty of the proper officer to see that g in good condition and receiving careful treatment.

point the writer would press is, that all in whose rtunity for registering facts in connection with uld by this or some recognised scientific Institution, te and carefully collect their information on all the at a certain average result for the guidance and sted may be arrived at.

ention should be given to ascertain the description tion of wheels, which in all points cause the least s on the axle; and for this he proposes to produce riments and also results from practice.

quality of lubrication and description of bearings considered, and for this he also proposes to give a tion, with the results of experiments and experience.

of most material advantage to all who are con- ave the management of machinery, whether for turing, or Mining purposes, to have their attention nomena bearing upon the nature, use, stability, and ron or other material of which that machinery is must be manifest that we must first obtain a clear est quality, the best form, and the best treatment and prepare it for use, and to preserve it from any s as far as possible, in order to obtain the greatest and economy in working the machinery for the led to effect.

With the above views kept prominently before them in all th enquiries in this as well as in other branches of practical researcl developing improvements of commercial utility, the Members of Institution, from their different positions, with large and varied opp tunities, will be enabled to effect great good; they will assist progress of useful Mechanical Inventions, and entitle themselves the respect and gratitude of all classes, as being the means of produc and encouraging lasting and substantial advantages to the commer and manufacturing interests of the country.

The CHAIRMAN remarked that it was much to be regret that their President, who took a great interest in the subject, absent, and perhaps it would be well not to conclude the inve gation that evening, in order to afford him an opportunity being present.

Mr. COWPER enquired with reference to the broken a exhibited, whether it had been nicked to a square shoulder broken to test the quality of the iron, or whether it had o been bent by pressure.

The CHAIRMAN replied, that the axle was broken at one e whilst running on the railway, and was broken off short off at other end by falling to the ground; and then in order to whether the crystallization was local or otherwise, it was aft wards bent in the centre by three or four blows from a weigh 17 cwt. falling upon it, without the axle being nicked, and it then doubled up by the hydraulic press, but it did not show a appearance of breaking.

Mr. WRIGHT observed, that the fracture was at a very de square shoulder, and a great deal of the appearance round fracture might be the result of the shoulder.

The CHAIRMAN replied, that this to a certain extent mi be the case, but even without the shoulder there seemed to be annular crystalline space going on forming.

Mr. WALTER WILLIAMS expressed his full concurrence the views stated by Mr. Gibbons in his communication, wh were founded on very long experience. He could also speak fr the experience of many years, that he had invariably found t iron much used as axles broke in the manner described by chairman. He was therefore quite satisfied that a change ta place in the structure of iron, and was rather surprised tha

was entertained, because he had observed hun-
es where after having produced a good tough
after hammering it had broken crystalline. But
l it was known that iron was affected in its struc-
ention that in making iron for particular pur-
rable to have it of very close fibre, and it was
ow the hot iron into a water bosh in the state
from the rolls, and that injured its fibre. The
ealing with the iron was to clean it, and when
n the rolls its fibrous character was restored;
opinion that in the case of axles deteriorated by
is character might be restored by drawing down
as no doubt it was the action of the wheels which
e.

considered the subject was one of great import-
sted that the discussion should be deferred until
rs had been furnished with a copy of the paper
ents, with such diagrams as were necessary for
n. So important was the question which pre-
n reference to changes in the structure of iron
pied the attention of the American Institute for
nd he thought that this Institution should not
t to pass without a long and careful considera-
was necessary to have regard to the various
nder which the iron was manufactured, and the
acter of the iron itself.

r Smith, in reference to his promise at the last
ish some results at the present meeting, observed
iments on cold-hammering iron, which were
. McConnell's paper, had been tried at his works
ncurred in all that Mr. McConnell had said with
m.

Jackson enquired which class of iron the chair-
best for railway axles—malleable iron or steel.
rt when he required great strength he employed
found that answer the best.

man in reply, repeated the first practical deduc-
in his paper, viz., "that the axles of all railway
ges, and vehicles should be made of the best ascer-

tained quality of iron for the purpose, both tough and stro and of uniform clean fibrous texture." That was his opini with reference to the quality of iron to be employed, and thought the Institution would be departing from its provi were it to consider any particular district or manufactu They were now treating of the *deterioration of railway axles*, a the question to be decided by proofs adduced to the memb was whether they underwent such a change as from fibrous crystalline iron; that question being determined, they mi then not only consider the quality of iron, but the form of r way axles most advantageous to be adopted.

Mr. Hodge observed, that when steel was employed it w in order to produce stiffness and not to resist torsion; he did think that the mere imparting of carbon to iron would giv the properties required for the present purpose.

Mr. Slate doubted whether the term fibrous, as applied iron, properly described the state or condition of the material which it referred. He could understand a fibre of cotton wool or other such material, but in the case of fibrous iron, a was termed, they found a series of small crystals united longi dinally giving the appearance of fibre, and when changed larger crystals the peculiar cohesion seemed to be destroyed, a the whole became a conglomerate mass without any appeara of fibre.

Mr. Cowper said, it appeared to him that fibre in iron w composed of the separate particles of iron existing in the puddli furnace of different sizes, and that these were afterwards elo gated in the process of forging and rolling, so that a number long particles were obtained lying near to each other thou there was not perfect contact owing to the interlying cind Crystalline iron was that in which the particles assumed a other form than the elongated form. All iron contained a p tion of cinder or silicate of iron, which was more or less squeez out in the process of forging and rolling.

Mr. Hodge remarked, that to arrive at any true results to the structure of iron it would be necessary to call in the aid the microscope, to examine the fibrous and crystalline structu

Mr. Walter Williams adverted to the well-known fact t the continued working of machinery, such for instance as t

gines, destroyed the fibrous structure of the iron
crystalline.

R remarked, that it was his opinion that iron
ne crystallized unless it was hammered or so
as to alter its form and produce a permanent set
m; he did not think however that an iron rail-
crystallized from the action of the concussions
cause he did not think that the effect produced
o cold-hammering; he thought a fair experiment
rn a square shoulder in the centre part of the
ch had been bent up by pressure, and then to
nick at the shoulder and see if it broke with a
alline fracture, for it was well known that by
vould break more crystalline.

illustrated the subject by reference to the effect
the journal of a picker shaft in a cotton mill, at
ica, where in order to produce stiffness a shaft of
introduced, but it frequently broke off at the
arly when there was a very tight belt on the drum.
st-iron $1\frac{1}{8}$ inch thick was then shrunk on the
in a brass bearing, and it then worked well.
uced this fact to show that the friction caused by
oduces a change in the molecular structure of iron.

did not think that from the mere appearance of
cture they could exactly determine the molecular
would recollect that Mr. Stephenson adverted to
its by Mr. Brunel, where from the mode of pro-
cture the same bar of iron gave out different
xperiments were perhaps conducted on too small
ish undeniable results, but he thought it quite
e same bar of iron should exhibit different results
owly in a vice or struck by a smart blow; in the
cture might be crystalline, but fibrous in the other.

said that he had tried an experiment with very
iron; he merely attached it to the head of a tilt
went about 300 strokes per minute, and after a
oke off brittle without any blow, although the iron
ough as it could be made, and this was attributed
ring.

Mr. HODGE observed, that this was quite analogous to results given in the report of the Commissioners on the experiments with reference to the duration of wire bridges in Fran that the effect was produced by the constant vibration or jarr between the particles of the iron.

Mr. P. R. JACKSON suggested that the opinion of the me ing should be taken whether the change took place or not ; the CHAIRMAN observed that such a course would be contrary the practice of the Institution.

Mr. WILLIAM SMITH said, that he produced two specim of ordinary puddled-bar iron 1⅛ inch square, on which he tried the effect of hammering ; the first piece was broken off fr the bar by 22 blows of a 14 lb. hammer, the bar having b nicked, and the fracture was very fibrous ; the second piece 7 inches length cut off from the same bar next to the first pie and he set it on an anvil and struck it 20 blows on the end, it was then nicked in the middle and broke off with a single li blow, and showed a square crystalline fracture ; another pi was then broken of the same end of the bar as the first piece ascertain if the quality of iron in the bar was the same, an required 21 blows to break it, and was similar in the fractur the first piece.

Mr. MIDDLETON remarked, that in taking off the tires fr the driving wheels of an engine he observed that the bolts w quite crystalline; he was quite satisfied there was a change. A with regard to the hammering which took place on the rails, his opinion, it was quite sufficient to cause the change obser in railway axles.

Mr. HEATON said, he fully concurred in all that had b said in favour of a change being effected in the structure iron. He considered the change was generally confined to so particular part, and the rest of the iron was not injured ; in machine for flattening button shanks, which gave a blow of ab 12 lbs. (mentioned in Mr. McConnell's paper), the constant act had the effect of breaking the levers, which showed a crystall fracture, although within half an inch from the part so brok the iron continued unchanged and quite fibrous. The same w observable in the cross pins of corn-spindles which frequen broke in a few weeks' wear, and he did not know which last

or iron, but he thought good scrap iron would piece of steel, but it would not last half the time ld swaging. In the example he produced of the fracture showed a vertical division, because ly at each side, but in the case of a railway axle ed a circular space in the centre because the nd the axle on all sides in succession.

consideration of the subject was then adjourned ting, and the CHAIRMAN said he hoped the ome forward with all the information they could upon a question of such importance; and for vould take every opportunity of trying further collecting facts with reference to it.

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g paper by Mr. W. A. Adams of Birmingham,

Y CARRIAGE AND WAGGON SPRINGS.

this paper is to discuss and analyse the various ions of springs now in use in Railway Carriages and out, to the best of the writer's knowledge and expe- tages and defects, and suggesting such improvements ill lead to better effect and economy in the use and

Bearing Springs are applied to carriages and waggons b and neutralise as far as possible the force and shocks to which the vehicles are exposed in their A perfect bearing or buffing spring would be that rb the entire power and space of the blow without rtia of the vehicle. This in practice is wholly im- varying loads on bearing springs and varying force on In bearing springs the nearest approach to perfection first class carriage, where the disproportion of total aded and unloaded is less than in any other vehicle. nt time, as far as the writer is aware, there is no y which Engineers or Manufacturers can ascertain ight, or quality of material to be used for effectually ay vehicle, and consequently the goods and mineral try, averaging from 35 to 40 cwt. per spring, is now which vary in weight from 35 to 110 lbs. each. object being in all cases to discriminate between good the writer has endeavoured to test the relative quality

of spring steel converted from Swedish and from English iron. For this purpose bars of ordinary spring steel were procured from various makers, some being English and the others Swedish; the bars were all 3 inches wide and $\frac{5}{16}$ inch thick. These bars were cut to equal lengths, marked, and then made into springs and tempered in the ordinary manner; each of the springs consisting of a single plate turned over into an eye at each end, and 18 inches long between the centres of the eyes. These springs were then proved in the presence of Mr. W. P. Marshall, by means of pressure applied at the centre of each spring, the spring being supported by a pin passed through the eye at each end, which rested on rollers to allow the ends to be drawn together freely when the spring deflected.

The results were as follows—

ENGLISH.

No.	Weight.	Deflection.	Permanent Set.
1.	15 cwt.	1 inch	no set
	20 ,,		$\frac{1}{2}$ inch
	25 ,,	Broken	
2.	15 ,,	$1\frac{1}{8}$ inch	no set
	20 ,,	$2\frac{1}{4}$ inch	1 inch
	25 ,,	Broken	
3.	15 ,,	$1\frac{1}{2}$ inch	$\frac{1}{2}$ inch
	20 ,,	$3\frac{3}{4}$ inch	$2\frac{1}{2}$ inch
	25 ,,	much set	
4.	15 ,,	$1\frac{3}{8}$ inch	$\frac{1}{4}$ inch
	20 ,,	$2\frac{1}{2}$ inch	$1\frac{5}{8}$ inch
	25 ,,	much set	

SWEEDISH.

No.	Weight.	Deflection	Permanent Set.
5.	15 cwt.	$1\frac{3}{8}$ inch	$\frac{3}{8}$ inch
	20 ,,	$3\frac{1}{2}$ inch	$2\frac{1}{8}$ inch
	25 ,,	much set	
6.	15 ,,	$2\frac{3}{4}$ inch	$2\frac{1}{8}$ inch
	20 ,,	Broken	
7.	15 ,,	$2\frac{3}{8}$ inch	$1\frac{5}{8}$ inch
	20 ,,	$4\frac{1}{2}$ inch	$3\frac{3}{8}$ inch
	25 ,,	much set	
8.	15 ,,	$2\frac{3}{8}$ inch	1 inch
	20 ,,	$5\frac{1}{2}$ inch	$4\frac{1}{4}$ inch
	25 ,,	much set	
9.	15 ,,	2 inch	$\frac{3}{4}$ inch
	20 ,,	$3\frac{3}{4}$ inch	$2\frac{1}{2}$ inch
	25 ,,	Broken	
10.	15 ,,	$3\frac{1}{4}$ inch	2 inch
	20 ,,	Broken	

From the foregoing experiments it appears that the elasticity, sustaining power, and toughness of the English steel was much greater than that manufactured from the Swedish iron.

The *Laminated Spring* is the most common form for the springs of railway vehicles, consisting of a number of plates, the taper being given by reducing the plates successively in length.

The principle for regulating the taper of the spring is to obtain an equal amount of strain or deflection from each particle of material. If some parts of the spring are deflected less than others, the amount of material might be reduced in those parts without impairing the sustaining power of the spring.

A laminated spring may be tapered either in breadth or thickness, but if parallel in thickness and all the plates the same length, each

e uniformly tapered in breadth so that each half of
uld be a triangle. In practice the plates of laminated
de parallel in breadth and thickness, inasmuch as the
the most economical form, and the taper is obtained as
ed by the different lengths of plates.
ng consisted of only one plate parallel in breadth but
ckness, such taper should be in the form of a parabola,
h is in proportion to the square of the thickness. This
n in Fig. 2, Plate 3, by the part A A.
late 3, represents one-half of an ordinary waggon bearing
2 is the same spring pressed flat, but supposing the
slide over one another.
pring consisted of a number of very thin parallel plates,
orm would be a uniform taper in thickness from the
ds the ends, as shown by the portion B B in Fig. 2,
trength of each part of the spring would depend upon
of plates at that part. In practice the most correct form
etween the two forms of the triangle and the parabola,
the triangle, as the thickness of the plates bears only a
ion to the average length.
ng shown in Fig. 1 is 3 feet 3 inches long, 3 inches wide,
es thick in the centre, and consists of 15 plates $\frac{5}{16}$ inch
ing only the outside plates, which are $\frac{3}{8}$ inch, according
practice to allow for the plate not being supported by
h sides.
spring were a single plate of the same total strength it
y $1\frac{1}{4}$ inch thick at the centre, and in the form of the
A in Fig. 2, but as it consists of a number of plates the
be a line beyond that curve.
aight line B B in Fig. 2 is drawn outside the curve, giving
per from the centre of the spring to the end of the second
g the top plate its full thickness to the end. This line
suitable to be adapted for the practical outline of the
e deviation from correctness is only very small and gives
inution in strength at the quarter length D, which is
practice, because the centre C is usually weakened by a
hole reducing the strength one-eighth at that point.
e B B is transferred from Fig. 2 to the curved spring in
viding the length of the top plate into 16 equal parts by
m 1 to 16, which are drawn vertical in Fig. 2, and radiating
e of the curve of the spring in Fig. 1. These lines being
al length in both cases give the curved line B B in Fig. 1.

The end of the top plate is lengthened and turned down at E to
a bearing to the spring.

The writer has in practice set out all springs required by hi
drawing through the extreme points C and E a circular arc of the
radius as the top plate of the spring. The line obtained by this m
is a singular instance of how near practice has approached theo
this simple method, the extreme difference being only $\frac{1}{8}$ inch.

The line H H is obtained in the same manner as before desc
excepting that the spring is not tapered to the centre, but to a
of 2 inches from the centre, viz., from C to H. This is the form
versally adopted, but it is clearly incorrect, as the centre is made
portionately weaker than the remainder of the spring, as well as
further weakened by the rivet hole through the centre.

The true and correct form of spring would be, that the cen
the spring should be at H, and the plates connected not by a rive
with a narrow hoop. In practice the spring is clipped to and bea
the axle-box at H, and consequently the mass of steel H to
entirely wasted.

In two plates of steel of the same length and breadth b
different thickness, the amount of deflection caused by the
weights is in proportion to the cube of the thickness, althoug
breaking strength is in proportion to the square of the thickness
sequently if one spring were made with plates double the thickn
those of another spring, the first would require only one-eight
number of plates, viz., one-eighth the weight of material to suppo
load with the same amount of deflection; but in that case the ext
the displacement of the particles of the steel in the thick plates
be double of that in the thin plates, and in the practical applic
of thick plates to springs it is necessary to limit the deflection
the above extent, as the double amount of deflection would bre
strain the particles, presuming that in the thin plates the par
were being strained to a reasonable extent.

The *Waggon Bearing Spring* in ordinary use on the Mid
London and North Western, and other Railways is shown in F
and is 3 feet 3 inches long, $6\frac{1}{2}$ inches camber, $4\frac{13}{16}$ inches thick
3 inches wide, consisting of 15 plates of which 2 are $\frac{3}{8}$ inch an
rest $\frac{5}{16}$ inch thick, and the spring averages in weight about 93 l

This spring is used to sustain loads not exceeding 6 tons o
four springs exclusive of the waggon body; the waggon body w
barely 2 tons, making the total load about 8 tons, or 2 tons per sp

experiments this spring deflects with

ton	2 tons	3 tons
inch	2 inches	$3\frac{1}{4}$ inches

flat without setting or breaking.

noted that in originally proving this spring flat it had 1, but that with the same extent of proof it will not again t, having this property in common with other materials.

g would well sustain a load of 3 tons in actual work, ions received upon the rails would probably not at any he deflection $\frac{1}{2}$ inch, consequently the load of 2 tons is l on a spring far too rigid, to the detriment of the road n, and the original first cost is considerably more than een.

various plans were adopted to lessen the friction at the rings by the use of rollers, but these plans are now nount of friction not being found practically detrimental.

s of the plates of laminated springs were formerly taness, but now the usual plan is to form the taper in the ting the plates at the ends in a triangular form. This d much more certain in its effect, is neater in appearper in manufacture. The cutting is generally performed ne shearing machine or between dies in a punching craps being used in the melting pot for cast steel.

presents the *Waggon Bearing Spring*, or more correctly in extensive use on the North Branch of the London 'estern, the South Staffordshire, Caledonian, and other ch may well be designated by the term *cheap*.

g is 2 feet 5 inches long, 4 inches wide, 2 inches thick, es, consisting of 4 plates $\frac{1}{2}$ inch thick, and weighs about al experiment furnishes the following deflections—

ton	2 tons	3 tons
inch	$\frac{3}{4}$ inch	$1\frac{1}{8}$ inch

the immense sustaining power of this spring has been re in the observations on thick and thin plates.

r has already endeavoured to explain that the ordinary) is too rigid, what therefore must be the wear and tear tyres, vibration to the axles, and general wear and tear and load caused by this rigid spring. Compared with ing affords less relief in the proportion of 6 to 16, and removed from the object required to be attained.

The *Waggon Bearing Spring* in extensive use on the Midla Great Western, and other Irish Railways, and on the London a North Western Railway, is the ordinary spring as in Fig. 1, but wi eyes rolled at the ends and hung on scroll-irons.

The advantages of this form of spring are the great space pass through and quickness of adaptation to the inequalities of the ro in consequence of the deflection of the end shackles caused by t deflection of the spring, and consequent elongation between the cent of eyes of shackles; also the rubbing friction at ends is almost entir obviated.

The disadvantages are first, that to carry a given load a mu greater quantity of material is required, as from the circumstance o great portion of the space between the sole-bar and the axle-box bei taken up by the scroll irons and shackles the radius of the curve of t spring is much reduced, and a thicker spring consequently required

Secondly, the tension on the sole-bars tending to hog the wagg frame, being the reverse of the action of the ordinary spring.

Thirdly, in consequence of the great space passed through by t deflection of this spring, the variations of the load will considera vary the height of the buffers from the rails.

Fig. 4 represents the now universal *Carriage Bearing Spri* originally introduced by Mr. Wharton on the London and No Western Railway, as the result of repeated practical trials and impro ments; theory would probably have never attained a similar result

The spring is 5 feet 3 inches long, 3 inches wide, $2\frac{13}{16}$ inches thi and consists of 9 plates $\frac{5}{16}$ inches thick; the ends of the plates what is technically termed long spear-pointed.

Fig. 4 represents the spring when loaded, and the peculiar caml before fixing is made by setting the plates entirely at the centre, inste of the plates being set into a curve throughout their whole length in other springs. In fixing this spring the tension-brace is adjus between scroll-irons, with intervening compensating shackles. T tension-brace is 3 inches by $\frac{3}{8}$ inch, and thickened at the ends to $\frac{5}{8}$ inch The spring is then compressed between the axle-box and the brace.

The action of the spring and brace is that of a lever spring co bined with a tension-brace, but the spring is so thoroughly overpowe by the leverage of the brace and the weight of the load, as to have lit or no power of reaction or displacing the inertia of the load, beyond th of recovering its original position, thus affording the well-known smoo ness and steadiness of action of this construction of carriage spring

The brace is acted upon principally at the point A, but neverthel

rom the road strikes the point B, and the spring and at that point, the curving and straightening of the npensated by the straightening and lengthening at C, ension at D being thus at all times about the same. e steadies and counteracts the power of the spring, and relieves the brace by sustaining it at A.

ation also affords the means of firmly attaching the pring and brace, and thus holding it independent of the h in this case are wholly *guards*, not *guides* the guards the axle-box on the edge or side. Thus the effects of of the road laterally and horizontally are only trans-dy through the elastic medium of the spring.

he same construction, but shorter and lighter, are now or Horse-boxes, Carriage-Trucks, and Break Vans.

Bearing Spring consists of four flat horizontal plates ches wide, and tapered in thickness from $\frac{1}{2}$ inch at the at the ends, and fastened in the centre and impinging . See Fig. 5, Plate 4.

seem to possess any advantage over the ordinary lami-cepting that the friction between the plates is entirely t the ends; but at the same time it must be borne in linary laminated springs the steel is rolled concave, ates bear at the edges only, which very considerably ion.

antages of this spring appear to be, firstly, that the of support are when the spring is weighed considerably e bearing, necessitating the use of deep scroll-irons in aring-blocks in waggons.

he manufacture is costly and uncertain, from the fact ng tapered in thickness and the difficulty of hardening lates that taper in thickness.

hen fixed with scroll-irons the sustaining power is rom its effect as a tension brace.

ow Spring of the size used for passenger vehicles is centre to centre of spring eyes, and the versed sine s when weighted; the plates are 8 inches broad in red in width to 5 inches at the eyes, and the thickness

tages of this spring are—

holds the axle-boxes without the intervention of the

guards in the same manner as previously described with reference the carriage bearing spring.

Secondly, that the top links permit the wheels, axles, and ax boxes to traverse laterally in passing curves and other impediments

Thirdly, that the quick adaptation of this spring to lateral a perpendicular blows preserves the intertia of the body almost who from displacement at moderate speeds.

The disadvantages are, that at high speeds and on a bad road t reaction of this spring is so great as to cause a rebound, and the grad ally increasing momentum from each successive blow occasions ve considerable oscillation.

This property has completely negatived its use for 4-wheel carriages; but it is now used successfully under the 8-wheeled carriag on the North Woolwich branch, and there works to considerable vantage, permitting the wheels to adapt themselves freely to t curves of the road. The oscillation is there almost wholly obviat from the fact that the blows are received upon eight points, and th the reactive power of a blow on one of the eight points is not su cient to disturb the inertia of a load.

The spring has been and is now used to a very considerable tent on 6-wheeled carriages in Germany; but it is to be observed th the speed on the Continent is generally slower than in England.

A Spiral Bearing Spring is represented in Fig. 6, Plate 4. T dimensions of these springs as used under the tenders of the Midla Railway were 9 inches height and 6 inches diameter, and they w made of $\frac{7}{8}$ inch round steel. Within this coil was fixed a second spiral smaller diameter coiled the reverse way to prevent the coils interferi

The action of a spiral spring is principally torsion of the st bar, through the angle A C B, and partly lateral deflection from t increase of diameter when the spring is compressed.

Practically the writer is not well acquainted with the use of th springs, but presumes that the following objections have been found practice; the spring bears upon the sole bar at one point, viz., over t centre of the axle-box, instead of at two points some 3 feet apa There is a much greater uncertainty in the degree of elasticity a supporting power than in flat springs composed of many plates, par from the greater thickness of steel causing uncertainty in the temperi and from the greater angular strain on the particles of the steel; t sudden blows experienced by railway springs requiring the thickn of the steel to be within a certain limit, say of $\frac{3}{8}$ inch or $\frac{1}{2}$ inch.

Buffer and Draw Springs. The ordinary Laminated Buffer a Draw Spring is 5 feet $4\frac{1}{2}$ inches long, $5\frac{7}{16}$ inches thick, and 3 inc

ng of 17 plates, the outside plates $\frac{3}{8}$ inches thick and $\frac{5}{16}$ inch; the camber when at rest being 13 inches. nciples of construction apply to this spring as to the ring spring in Fig. 1.

rings are generally fixed in the centre of the carriage, n four bars of iron, ordinarily termed the "buffer spring ends are acted upon by the four buffer rods, and the draw l to the centre of the spring. The same methods have obviate friction at the ends as have been already men-spect to bearing springs, but these plans are now obsolete. the springs on carriages they are generally compressed l in waggons to the extent of about one-third of the stroke of the buffer rod is limited to such an extent as ct the spring beyond a straight line.

aining power of this spring is equal to about 2 tons 14 l in all, including both ends of carriage, to about $2\frac{3}{4}$ ed through a stroke of 2 feet.

this method of buffing has not been surpassed or one of the modern substitutes will give this moderate sisting power developed through so great a space as 2 e weight of the buffer springs being in the centre of the the springs acted upon by long buffer rods, cause the ery steady.

ble Draw Springs, with a Check bar to limit the action training point make probably the only truly effective dopted. It is to be observed that the springs when are limited in their action by the check bar A A, thus tinuous rigid draw bar. See Fig. 7, Plate 4.

ngs are each 2 feet long, $3\frac{9}{16}$ inches thick, and 3 inches ng of 11 plates, of which 2 are $\frac{3}{8}$ inch thick and the inch; the camber is $3\frac{1}{2}$ inches before fixing; the springs pressed $\frac{1}{2}$ inch in fixing. The method of fixing is the dy described for the laminated buffer spring.

Buffers. Within the last few years a considerable xternal Buffers have been introduced, consisting of a Piston packed with nearly every available elastic sub-ractically varying only in the material of the packing.

ue's Buffer Spring is packed with rings of vulcanised there are 4 rings $5\frac{1}{2}$ inches diameter, and $1\frac{1}{4}$ inch h.

In the opinion of the writer this is the least effective of any produced, as the stroke is very short, and then only moderately developed under enormous pressure. It is questionable whether in event of a collision the train would not collapse and leave the rails fore the immense sustaining power of these springs was fully develo

This buffer has an apparent stroke of about 3 inches; b appears that to drive up the pair of buffers 1½ inch would requ force of 3 tons.

By reference to the description of the ordinary laminated sp it will be observed that the stroke is 12 inches with a force of 2¾ being 8 times the length of stroke with a rather less force.

It it also questionable whether the vulcanised india-rubber that imperishable nature originally supposed. The writer has ha his possession a considerable quantity of vulcanised elastic band papers that have become completely rotten.

Todd's Cork Buffer is as nearly as possible the same as Bergue's, excepting that the packing is cork; there are 5 plat cork 7¼ inches diameter and ¾ inch thick.

This spring appears to be superior to De Bergue's inasmuc the cork is more compressible than the vulcanised india-rubber, b is questionable whether the cork is not liable to a permanent set.

Adam's Disk Buffer has the packing consisting of 16 disk sp made from flat circular plates of steel 8 inches diameter and ⅛ thick, with a radiating piece A A cut out to enable the plates t pressed to a conical form. See Fig. 8, Plate 4.

This buffer spring is superior to the foregoing inasmuch as total amount of stroke is wholly developed, and the power can be perly adjusted by the thickness of the plates; the total lengt stroke is 5½ inches.

Webster's Air Buffer exhibits considerable ingenuity, but is complicated than the other plans. The air piston is 6 inches meter, and the leather packing is distended by a vulcan india-rubber ring; the length of stroke is 4 inches.

In the event of leakage during the stroke, the piston would return to its original position, and to effect this a small spiral spri employed which drives back the piston. A small valve admits a the time that the piston is recovering its position to compensate leakage during the stroke.

Spiral Buffer and Draw Springs are used to some extent, they are liable to the same objections already described with refer to the spiral bearing springs.

cal Spiral Spring Buffer appears to be the least
ese, it is shown in Fig. 9, Plate 4. The resisting
spiral spring made in the form of a cone 7½ inches
se, and the spring has the advantage of rotating at
one, thereby considerably easing the tendency to
the particles of the steel; the steel is 1 inch wide
t the base of the conical spiral, and is tapered for
to ½ inch diameter at the point of the cone. When
pring forms a complete flat volute.
g power of the spring is about equal for the space
that of the ordinary laminated buffer spring, but
oke, the length of stroke being only 3½ inches in-
From its compactness and comparatively moderate
writer's opinion, should the springs be found to
the most eligible of the external buffers, but yet far
result obtained by the use of the laminated buffer
rods.

the Cylinder and Piston Buffers are liable to the
n being guided through only a short length, and con-
not work with the smoothness of the long buffer rod
places. This more particularly applies in the event
upon the buffer.
it is suggested that it would be desirable for a
formed of the sizes, weight, sustaining power, and
nated bearing and buffing springs, as a uniform
ctical application.
urposes, should it be desired by the meeting, to pre-
waggon bearing spring, with axle-box and adjust-
n the principles pointed out at the commencement
, to obtain the present amount of efficient results
quantity of material.

ETON remarked, that the conical spiral-spring
nentioned in the paper as the most advantageous
uffers in respect of the length of stroke, but that
ngth of stroke was required; and he wished to
he had introduced, consisting of a double-coned
ich had the advantage of giving a greater length
e thought would form a very satisfactory buffer.
pplied for the purpose of making a long buffer
by using 6 of these springs, 4 in the middle and
the buffer rod.

Mr. Adams observed, that an objection to the double-spring would be that it was not free to revolve on its ax the single-coned spring whilst it was being compressed, be it rested on the large base of the cone at each end, and the fi would be too great to allow of its revolving, but the single-spring had so little friction at the small end that it was ca of revolving when compressed. The strain on the steel was increased if a spiral spring was prevented from revolving compressed, and it was consequently more liable to break.

Mr. Middleton did not understand that it was imp for the spiral spring to revolve when compressed.

Mr. Cowper observed that he agreed with the obj made by Mr. Adams; the spiral would necessarily revolv certain extent when compressed unless prevented by som struction, because the length of each coil of the spiral was greater than the circumference of the circle.

Mr. Hodge remarked, that the double-conical sprin not a new invention; and Mr. Middleton replied that he d claim the invention of the spring, but he considered th application to the purpose suggested was entirely new.

Mr. Fuller wished to state (for Mr. De Bergue absence), with respect to the vulcanised india-rubber in springs, that upwards of 100,000 of the rings had been sen and many of them had been in use for two or three years, far as he had ascertained the cases of failure had been ver indeed. In some cases where the material had been us bearing springs it had failed in consequence of not hav sufficient amount of bearing surface, but in the applicat buffer springs he was not aware of any instance of failure e ing in a few cases where the rings had been over vulcanise

Mr. Adams replied, that he had not had any experie the durability of the vulcanised india-rubber applied to b and he had therefore only stated the circumstance he wa quainted with of the bands for papers.

The Chairman thought it would be better to defer th cussion upon the paper until the members had been su with a copy in the proceedings of the meeting, and they then be better enabled to bring such facts and experience a had to bear upon the subject. He thought that Mr. Adam

ıanks for the careful research he had exhibited
:h was one of great value and importance; he
who spared no pains to improve every part of
ı they were engaged. He hoped the Institution
: similar communications from many others of
practical subjects connected with the various
vhich they were engaged.

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g paper by Mr. William Smith of Dudley, was

ENSATION OF STEAM IN THE ENGINES
UTH STAFFORDSHIRE IRON DISTRICT,
IMPROVEMENTS TO BE EFFECTED IN

the present paper, with the accompanying Indicator
ɔw the present working condition of forty-eight of
Mill, Forge, and Blast Engines in South Stafford-
marks as to the practicability of improving them.
ying Indicator Diagrams have been enlarged from
which were taken from the Engines by the writer
er.

ıred Red represents the steam pressure above the

ıred Yellow shows the amount of vacuum by con-
e atmospheric pressure.
t represents the difference between a perfect vacuum
the actual working of the Engines, showing the in-
ıt would be obtained if a perfect vacuum could be
hout the whole length of the stroke; and the large
lue part express the number of pounds on the square
gine is deficient in forming the said perfect vacuum.
1 to 27 inclusive are taken from Forge and Mill
nary construction of Boulton and Watt's Condensing
ıeters of the cylinders range from 29 to 48 inches, the
ɔm 5 to 8 feet, and the number of strokes per minute
e valves in most of them are on the double-beat prin-
rs are the old hollow-stalked conicle valves, most of
ɔy hand gear and a few with eccentric motion.
44 are from Blast Engines of similar construction,
hich range from 32 to 59 inches diameter, the length
o 8 feet, and the number of strokes per minute 8 to

17; the description of the valves and mode of working them are t same as in the Forge and Mill Engines; most of them work with parallel motion at each end of the beam, one for the Steam and t other for the Blast Cylinder, and a few of them are Crank Engin with the Blast Cylinder placed directly under the Steam Cylinder.

Figure 45 (see Plate 6) is from a Crank Engine for drivi machinery in London, the cylinder is 30 inches diameter and 2 fe 6 inch stroke, and working 36 strokes per minute with double-be valves, and cutting off the steam at $\frac{1}{8}$ of the stroke from the co mencement.

Figures 46 and 47 (see Plate 6) are from a pair of Blast Engin in this District working coupled together, the cylinders are 42 inches d meter, length of stroke 8 feet 3 inches and making 14 double strok per minute; they are both fitted with double-beat valves. In Figure the valves are worked by wheel-work from the crank shaft, and cutti off the steam at $\frac{1}{4}$ of the stroke; in Fig. 46 they are worked by eccentric motion, and the steam is cut off by a separate valve placed the steam pipe, and from the circumstances of that valve being farth away from the steam port it will be seen that a different form is giv to the line of expansion, and an inferior effect is produced.

Figure 48 is from a Mill Engine in this District with 36 in cylinder and 7 feet 2 inch stroke, making 17 double strokes per minu this Engine was recently altered from low pressure and fitted wi expansive gear cutting off the steam at $\frac{1}{10}$ of the stroke from the co mencement.

From Figures 1 to 27, Forge and Mill Engines, the gene character of the Diagrams shows a considerable pressure of stea throughout the whole length of the stroke, averaging about 12 lbs. up the square inch above the atmospheric line, and reaching only from 7 11 lbs. at the end of the stroke, the average vacuum being about lbs. on the square inch below the atmosphere throughout the stroke

In the second set, Nos. 28 to 44, Blast Engines, the grea number are similar to the preceding, the steam pressure being co tinued nearly uniform to the end of the stroke, averaging about 7 l to the square inch, and an equally defective vacuum, commencing the atmospheric line and reaching from 7 to 10 lbs. at the end of t stroke, the average vacuum being about 7 lbs. per inch below t atmosphere throughout the stroke.

Several of the remaining Diagrams of this class show considera expansive action but not a good vacuum, which is strikingly visible putting them in contrast with Nos. 46 and 47, which show mu better effect in their expansive and condensing operations combined

17 (see Plate 5) in the first series of Diagrams repre-
igines of 42 inches cylinders and 7 feet stroke, making
ninute, which were working very imperfectly in the
their steam, and have been improved to a remarkable
ration made for the purpose of improving the vacuum,
d a very considerable saving in the consumption of fuel.
king with $19\frac{1}{2}$ lbs. pressure of steam at the beginning
ntinued to 18 lbs. pressure at the middle, and reduced
at the end of the stroke, by wire-drawing the steam
off expansion valve, the average pressure being 16·37 lbs.
ch throughout the stroke, and the average vacuum was
the square inch below the atmosphere, beginning a
atmospheric line and reaching only 5 lbs. below the
ne end of the stroke. This performance being so bad,
l necessary to examine the Engine, and the cause was
n the valves thoroughfares and condenser being much
ne proper proportion, the steam and eduction valves
ches diameter and the thoroughfares of the same size;
fore removed and replaced by others, the steam valves
ter, the eduction valves and thoroughfares 12 inches
ee times the area of the original ones. The condenser
doubled in capacity by attaching a large vessel on the
made it rather larger than the regular proportion;
as only 24 inches diameter with half the stroke of the
about one-fifth less contents than the regular propor-
of the cylinder; this was not altered, but there was
pply of cold water for injection.
of the above alteration is shown in Fig. 12 A (Plate 5),
ure being 8 lbs. at the beginning and reduced to about
at the end of the stroke, the average pressure being
d of 16·37 lbs. on the square inch throughout the
um commenced at $10\frac{1}{2}$ lbs. and ended at 11 lbs., the
0·15 lbs. instead of 2·72 lbs. on the square inch below
throughout the stroke. The improvement in the
ts therefore to an average of 7·43 lbs. on the inch
stroke; the total power of the Engine as shown by the
as 19·09 lbs. per inch on the piston throughout the stroke,
e power, and this improvement of the vacuum amounted
of the power of the Engine, or 74 Horse power.
e from which No. 17 Diagram (Plate 5) was taken was
and the valves and thoroughfares were found to be
eter, but the valves had not sufficient lift; the eduction
denser was 9 inches diameter, and the condenser itself

was 2 feet 4 inches diameter and 4 feet 6 inches high; the educt pipe was then removed and replaced by one 12 inches diameter, als large vessel was fixed on the top of the condenser which increased capacity about one-third; the lift of the valves was then increa from $1\frac{1}{8}$ inch to $2\frac{3}{8}$ inches, and the result of the alteration is she in the Diagram 17 A., which shows an improvement in the avera vacuum of from 1·50 lbs. to 7·97 lbs., or 6·47 lbs. per square in increase of pressure throughout the stroke.

The saving of fuel from these alterations has not been w ascertained, as the Engines in both cases are worked from a series boilers which also supply steam to other Engines upon which the lo is very unequal; but it is admitted to be very considerable, and the case of No. 17 the parties have been enabled to use an infer description of slack, and also to throw off one boiler having a fi grate about 7 feet square and 45 square yards of heating surfa without any dimunition in the power employed.

The aggregate power of the 45 Mill, Forge, and Blast Engin shewn in the Diagrams is nominally 3240 Horse power, according Boulton and Watt's proportions of the cylinders, but by the calculat of the Indicator Diagrams, the total is 7819 Horse power. The avera vacuum obtain in the present working of all these Engines is abo 6 lbs. per inch below the atmosphere throughout the stroke, omitti from the average Nos. 5, 6, 35, and 37, which are exceptions to t general run of these Engines; and the average vacuum obtained in t 6 Expansive Engines is $10\frac{1}{2}$ lbs. per inch below the atmosphe throughout the stroke. The loss of power from the imperfect vacuu in the former Engines may therefore be taken at the difference betwe these pressures, or $4\frac{1}{2}$ lbs. per square inch pressure throughout the strok which amounts to 1930 indicated Horse power upon these 45 Engine or in other words, an additional power of 1930 Horse power, or 25 p cent. increased power might be obtained from the same expenditure Steam and consequently of Fuel, if the vacuum were improved so as be as good as the average of the 6 Expansive Engines, or $10\frac{1}{2}$ lbs. p inch throughout the stroke. This vacuum has been nearly obtain in both the Engines Nos. 12 and 17, which have been altered as befo described, and in these Engines the alteration was carried out only to limited extent and at a comparatively trifling expense; but to carry out efficiently by attaching Expansive gear in addition to what had be done, a much better effect would be obtained by using the same volum of Steam expansively. In Diagram No. 45 the steam is cut off $\frac{1}{8}$ of the stroke, and the vacuum averages 11·80 lbs. per inch inste of $10\frac{1}{2}$ lbs. per inch, the average of the 6 Engines taken above.

dent of the loss sustained by not working expansively, r in these 45 Engines being 1930 Horse power as annual loss in money by extra consumption of fuel calculating 20 lbs. of slack per hour for each Horse f 3s. per ton, will amount to £18,610, or £2 7s. 7d. per annum.

ver of the Steam Engines employed in the manufacture istrict may be computed to be ten times the nominal ed, and the total annual loss to the proprietors from the in the present paper may be taken in round numbers annum, as the 45 non-expansive Engines described isidered a fair average of the Engines in the District. generally considered hitherto, that the improvement on of steam was not applicable advantageously to the listrict, because of the small cost of the fuel employed; seen to be an erroneous conclusion from the actual erations described above, where the improvement was he vacuum, and the expansive principle was not carried d have effected a still greater economy. The total consumed at present is so large that although the insignificant, the total amount of saving effected by on the whole is very important. In addition to the fuel consumed, a very important saving would also e tear and wear of the boilers, which is fully in pro- xtra fuel burnt under them, and the repairing of which ended with serious inconvenience and expense.

tion of boilers in general use in the District, and the o be effected by improvements in their construction tting is also an important practical subject for con- t is intended to form the subject of another paper, to e Institution at a future meeting.

YLINDERS AND LENGTH OF STROKE OF THE ENGINES.

	in.		ft.	in.		per minute.	
l Mill Engine,	38	Cylinder	7	0	Stroke	16	Strokes
ditto	34	,,	6	0	,,		
ditto	48	,,	7	0	,,		
ine	44	,,	7	0	,,		
gine	34	,,	6	0	,,		
itto	32	,,	6	0	,,		
ine	38	,,	7	0	,,	19	,,
itto	30	,,	5	6	,,	21	,,
d Mill Engine	42	,,	7	0	,,	18	,,

No.		in.		ft.	in.		per
10	Forge Engine	42	Cylinder	8	0	Stroke	17
11	Ditto ditto	46	,,	8	4	,,	16
12	Mill Engine	42	,,	7	0	,,	16½
13	Ditto ditto	42	,,	7	10	,,	18
14	Forge and Mill Engine...	43	,,	7	5	,,	17½
15	Forge Engine	36	,,	7	5	,,	15
16	Mill and Forge Engine...	34	,,	5	6	,,	24
17	Ditto ditto ...	42	,,	7	6	,,	17
18	Forge Engine	42	,,	7	6	,,	17
19	Ditto ditto	36	,,	5	0	,,	23½
20	Mill Engine	36	,,	6	0	,,	18
21	Forge ditto	29	,,	5	0	,,	21
22	Mill ditto	40	,,	7	0	,,	18
23	Ditto ditto	42	,,	7	0	,,	17
24	Forge ditto	40	,,	7	0	,,	18
25	Mill ditto	36	,,	6	6	,,	18
26	Forge ditto	33	,,	7	6	,,	17
27	Mill ditto	40	,,	6	0	,,	18
28	Blast Engine	42	,,	7	6	,,	16
29	Ditto ditto	36	,,	8	0	,,	14
30	Ditto ditto	36	,,	8	0	,,	14
31	Ditto ditto	46½	,,	8	0	,,	17
32	Ditto ditto	32	,,	7	6	,,	14
33	Ditto ditto	44	,,	8	0	,,	16
34	Ditto ditto	44	,,	7	0	,,	8
35	Ditto ditto	45	,,	8	0	,,	11
36	Ditto ditto	56	,,	8	0	,,	12
37	Ditto ditto	51	,,	8	0	,,	11½
38	Ditto ditto	59	,,	7	6	,,	11½
39	Ditto ditto	32	,,	8	0	,,	13
40	Ditto ditto	46½	,,	8	0	,,	13
41	Ditto ditto	48	,,	7	0	,,	14
42	Ditto ditto	35½	,,	6	0	,,	8½
43	Ditto ditto	24	,,	5	0	,,	24
44	Ditto ditto	42	,,	8	0	,,	12
45	Factory Engine...........	30	,,	2	6	,,	35
46	Blast ditto	42	,,	8	3	,,	14
47	Ditto ditto	42	,,	8	3	,,	44
48	Mill ditto	36	,,	7	2	,,	17
49	Ditto ditto	42	,,	7	0	,,	16
50	Factory ditto	36	,,	6	0	,,	22
51	Ditto ditto	36	,,	6	0	,,	22

id, that he could testify to the accuracy of many
iagrams given by Mr. Smith, and to the value
paper.

ɴ observed, that as there was no time to discuss
tant paper at that meeting, it would be better to
xt meeting, and in the meantime the Members
ortunity of considering the paper in detail.

resented to the Institution a copy of his work
l Principles of the Expansive Steam Engine."

then terminated; and a large party of the
friends dined together in the evening.

INSTITUTION OF MECHANICAL ENGINEE

REPORT OF THE COUNCIL,

THIRD ANNUAL MEETING, 23RD, JANUARY, 185

The Council have great satisfaction in congratulating Members at this Third Annual Meeting, on the steady prog of the Institution, and its increasing efficiency in accomplish the objects intended.

The number of Members has increased to 201 during last year, 18 of whom are Honorary Members.

The Financial Statement of the affairs of the Institution the year ending 31st December, 1849, shows a Balance in Treasurer's hands of £195 11*s.* 3*d.*, after the payment of accounts for the year 1849, and this Balance has been increa to £216 11*s.* 3*d.* by the receipt since 31st December of so subscriptions due for the year 1849.

The Council have been particularly careful to exerc economy in the affairs of the Institution, and to avoid all exp diture not advantageous or necessary. A considerable sum been invested for the benefit of the Members in Mechani Engravings, which have been supplied to the Members, and t arrangement appears to have met with their decided approv and there are still a number of copies on hand, for sale to th Members or their friends who may wish to procure copies these excellent engravings.

The Finance Committee have examined and checked all t receipts and payments of the Institution for the year 1849, a have reported that the following Balance Sheet rendered by t Treasurer is correct.

ION OF MECHANICAL ENGINEERS.

BALANCE SHEET,

the year ending 31*st December*, 1849.

	£	s.	d.	Cr.	£	s.	d.
om 6 old				By Stationery and Printing			
g arrears				&c.	80	13	0
....	18	0	0	— Office Furniture	1	8	6
om 153				— Petty Disbursements and			
for 1849	459	0	0	Office Expenses	14	15	9
rom 22				— Travelling Expenses	6	9	9
for 1849	110	0	0	— Reporting	16	18	0
Peter				— Parcels	13	10	3
....	5	0	0	— Postages	24	2	7
advance				— Hire of Rooms for Meet-			
....	3	0	0	ings	4	4	0
phs......	3	8	0	— Lithographing	315	10	0
Subscrip-				— Salaries	305	17	6
Annual				— Rent of Office	45	0	0
....	1	8	6	— Balance	195	11	3
1st Dec-							
....	424	4	1				
	£1024	0	7		£1024	0	7

(Signed) E. A. Cowper.
Wm. Buckle.

il have the pleasure of announcing that the fol-
nave been presented to the Institution during the

the Commission for Inquiring into the Application
on to Railway Structures, from the Commissioners.
dgkinson on the Strength of Cast Iron, from the
or.
Railway Wheels, from the Author.
he Aneroid Barometer, from the Author.
Indian River Navigation, from the Author.
ical Mechanic's Journal, from the Editor.
anic's Magazine, from the Editor.
Engineer and Architect's Journal, from the Editor.
an, from the Editor.
t Journal, from the Editor.
Dictionary of Engineering Terms, from the Editor.

The following Papers have been laid before the Institut and discussed at the Meetings during the past year.

On a Station Buffer ....by	*Mr. C. D. Bergue*
— Improved Railway Chairs & Switches	*Mr. W. Baines.*
— The Construction of Permanent Way	*Mr. J. W. Hoby.*
— A Solid Wrought-Iron Wheel	*Mr. H. Smith.*
— Railway Axles..........................	*Mr. J. E. McConn*
— The Economy of Railway Transit ...	*Mr. J. Samuel.*
— An Express Engine....................	*Mr. W. Weallens.*
— An Improved Locomotive Boiler ...	*Mr. J. Ramsbotton*
— The Expansion of Steam	*Mr. W. Fairbairn*
— A Patent Starting Apparatus.........	*Mr. J. Hick.*
— An Engine Counter	*Mr. J. Richmond.*
— Nasmyth's Patent Girders	*Mr. S. Lloyd.*
— A Pneumatic Lift	*Mr. B. Gibbons.*
— The Ventilation of Wallsend Colliery	*Mr. D. Burn.*

The Council wish particularly to draw the attention of Members to the List of Proposed Subjects for Papers, whicl appended to this Report; this List has been sent to them o former occasion, and the Council hope that every Member choose some one or more subjects on which he will prepa communication in the ensuing year; they also earnestly requ that each Member will afford all the assistance in his powe advancing the objects and increasing the utility of the Institut by forwarding the results of Experiments, and of the practi working of old and new Machinery, Engines, &c., &c., so as render the Institution a complete place of reference for Members on any Mechanical subject.

The number of Papers and Communications received fr the Members has not been such as to occasion the propo additional Meetings in London and Manchester during the p year.

The Officers of the Institution and Five of the Members Council go out of office this day according to the Rules, and ballot will be taken at the present meeting for the election Officers for the ensuing year.

POSED SUBJECTS FOR PAPERS.

LERS, particulars of construction—form—heating surface—cost
of fuel—evaporation of water—pressure of steam—steam
pressure and low pressure—explosion of boilers and means of
fects of heat on the metal of boilers, low pressure and high
station of boilers and means of prevention—evaporative power
of different kinds of fuel, coal, wood, charcoal, peat, patent
—smoke consuming apparatus, best plan and results of working.
orce and best means of using it—power obtained by various
ison of double and single cylinder engines—indicator figures
with details of useful effects, consumption of fuel, &c.—contri-
icator figures for a general book of reference to be kept in the

particulars of various constructions—size of cylinder, strokes
nd horse power—number and size of pumps and strokes per
cation of pumps—fen draining engines.

est kind of engine—size of cylinder, strokes per minute, and
-number of boilers—size of blowing cylinder and strokes per
s of regulating the blast—improvements in blast cylinders.

power of engines in proportion to tonnage—different construc-
es—comparative economy and durability of different boilers,
, &c.—weight of machinery and boilers—kind of paddle wheels
ed in British war steamers, in British merchant steamers, and
tto, with particulars of the construction of engines and paddle
crew propellers, particulars of different kinds, number of arms,
s for unshipping, horse power applied, speed obtained, section

particulars of construction and practical application—details of
working.

NES, express, passenger, and luggage engines—general par-
nstruction, details of experiments, and results of working—
ines, cost, power, weight, steadiness—consumption of fuel—
e, length and diameter of tubes—experiments on size of tubes
—comparative expense of working and repairing—best make of
gear, &c.

particulars of construction and dimensions—form and depth of
d of water, velocity, per centage of power obtained—scoop wheels
-turbines, construction and practical application, power obtained,
ffect and economy.

ticulars of construction—number of sails, surface and form of
, and power obtained.

articulars of improvements—power employed—application of
-results of working with an air blast—advantages of regularity of

ticulars of the construction and working—results of the applica-
ydraulic press.

Saw Mills, particulars of construction—mode of driving—power employed—p ticulars of work done—best speeds for vertical and circular saws—form of s teeth.

Oil Mills, facts relating to the construction and working.

Cotton Mills, information respecting the construction and arrangement of t machinery—power employed, and application of power—cotton presses, m of construction and working, power employed.

Rolling Mills, improvements in machinery for making iron and steel—mode applying power—steam hammers—piling of iron—plates—fancy sections.

Stamping and Coining Machinery, particulars of improvements, &c.

Paper Making and Paper Cutting Machines, ditto ditto

Printing Machines, ditto ditto

Calico Printing Machinery, ditto ditto

Water Pumps, facts relating to the best construction, means of working, a application—best forms—velocity of piston.

Air Pumps, ditto ditto ditto

Hydraulic Presses, facts relating to the best construction, means of working, a application.

Fire Engines, ditto ditto ditto

Sluices, ditto ditto ditto

Cranes, ditto ditto ditto

Lifts for raising Trucks, &c. ditto ditto ditto

Blowing Fans, particulars of the best construction, and results of experiments.

Lathes, Planing, Boring, and Slotting Machines, &c., particulars of impro ments—description of new self-acting tools.

Toothed Wheels, best construction and form of teeth—results of working.

Driving Belts and Straps, best make and material, leather, rope, gutta perc &c.—comparative durability and results of working—power communicated certain sizes.

Strength of Materials—facts relating to experiments on ditto, and gen details of the proof of girders, &c.—girders of cast and wrought iron, parti lars of different constructions, and experiments on them—best forms proportions of girders—best mixtures of metal.

Durability of Timber of various kinds—best plans for seasoning timber cordage—results of Kyan's, Payne's, and Burnett's processes—compara durability of timber in different situations.

Corrosion of Metals by salt and fresh water, and by the atmosphere, &c.—f relating to corrosion, and best means of prevention.

Alloys of Metals—facts relating to different alloys.

Friction of various Bodies—facts relating to friction under ordinary circ stances—friction of iron, brass, copper, tin, wood, &c.—proportion of we to rubbing surface—best forms of journals, &c.—lubrication, best mater and means of application, and results of practical trials—best plans oil tests.

Iron Roofs, particulars of construction for different purposes—durability in var climates and situations—comparative cost, weight and durability—roofs slips of cast-iron, wrought-iron, timber, &c., best construction, form, material.

Fire-Proof Buildings, particulars of construction—most efficient plan—re of trials.

of large size, particulars, mode of building, &c.
ure and durability—fire-bricks and fire-clay.
t form, size, and material for retorts—construction of retort ovens
nd quality of gas from different coals—improvements in purifiers,
and gas-holders—wet and dry gas-meters—pressure of gas, gas
gas pipes, strength and durability, and construction of joints—
e diameter and length of gas mains, and velocity of the passage
eriments on ditto, and on the friction of gas in mains and loss of

—facts relating to water works—application of power, and economy
—proportionate diameter and length of pipes—experiments on the
of water from pipes, and friction through pipes—strength and
of pipes, and construction of joints.
and ARTESIAN WELLS, facts relating to.
nd PILING, facts relating to the construction.
floating, and Pontoons, ditto ditto
APPARATUS, particulars of improvements—use of steam power.
CHINES, particulars of improvements—application of dredging
-power required, and work done.
facts relating to the best construction.
HTHOUSES, ditto ditto
IONS, facts relating to mining—means of ventilating mines, use of
nd ventilating machinery—mode of raising materials.
relating to blasting under water, and blasting generally—use of
, &c.
s—consumption of fuel in different kinds—burden, make, and
metal—pressure of blast—horse power required—economy of work-
ovements in manufacture of iron—comparative results of hot and

ACES, best construction—consumption of fuel, &c.
, best construction—size and material—power of blast.
RCOAL, particulars of the best mode of making.
struction of permanent way—section of rails, and mode of manu-
xperiments on rails, deflection, deterioration, and comparative
—material and form of sleepers, size, and distances—improvements
eys, and joint fastenings.
CROSSINGS, particulars of improvements, and results of working.
articulars of various constructions and improvements.
tions and Trains, and self-acting signals.
riages and Waggons, best construction.
Carriages, &c., and Station Buffers—different constructions and

rriages, &c., buffing and bearing springs—particulars of different
ns, and results of working.
ELS, wrought iron, cast iron, and wood—particulars of different con-
and results of working—comparative expense and durability—
on and steel tires, comparative economy and results of working.
s, best description, form, material, and mode of manufacture.

The Council invite communications from the Members and their friends, o the preceding subjects, and on any engineering subjects that will be useful an interesting to the Institution; also presentations of engineering drawings, model and books for the library of the Institution.

The communications should be written on foolscap paper, on one side only each page, leaving a clear margin on the left side for binding; and they should written in the third person. The drawings illustrating the communications shoul be on so large a scale, as to be clearly visible to the meeting at the time of readir the communication, or enlarged diagrams should be sent for the illustration of ar particular portions.

INSTITUTION

OF

MECHANICAL ENGINEERS.

PROCEEDINGS.

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UNCIL, 1851.

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PROCEEDINGS.

APRIL 24, 1850.

GENERAL MEETING of the Members was held in of the Philosophical Institution, Cannon Street, n, on Wednesday, the 24th of April, 1850; ROBERT N, ESQ., M.P., President of the Institution, in the

ites of the last General Meeting were read by the and confirmed.

IRMAN then said the adjourned discussion on les and the fracture of iron would be opened by w additional observations by Mr. J. E. MCCONNELL,

DETERIORATION OF RAILWAY AXLES.

the discussion on Railway Axles, adjourned from eting, it will be only requisite to refer to the former have been laid before the Institution on the form of heir deterioration from work.

egards the proper form for a Railway Axle, the pro- shown in which the diameter of the Axle should be n the back of each wheel towards the centre, so as to ual strength throughout the length of the Axle, to resist or blows to which it is subjected. This was tested in t ways, in the one case by a steadily increasing pres- n the other by the blow of a weight of 17 cwt. falling he force in both cases being applied at the same

point—namely, at the outer end of one wheel whilst the opposi wheel was fixed. The result given by these tests was, that t Axle, when shaped in the proportion ascertained by previo calculation and experiment, was bent into a nearly unifor curve, showing that the object of obtaining an equally propo tioned strength was practically accomplished. It may observed also, that the general experience of practical Enginee engaged in the management of Railway Rolling Stock appea to confirm this principle.

2nd. As to the deterioration that takes place in Axles, and t change in structure caused by the course of working, sever cases were instanced, and specimens were laid before the Ins tution of broken Railway Axles, showing the crystalline appea ance of the fracture. The writer considered that a change w produced from a fibrous to a crystalline structure by the effec of the concussion or jarring that the Axles are subjected whilst running on the Railway; and it appears to be genera considered that such change takes place to a greater or l extent according to the circumstances, both in Railway Ax and in many other cases where iron is exposed to concussion jarring, though there may be a difference of opinion as to t cause of the change. Another striking instance of the conversi of tough wrought iron into a brittle material is shown in t chain slings used for carrying the bars during the process of ha mering at a forge: the writer lately had an opportunity of obser ing a chain which had been in use for this purpose, and h become so extremely brittle, that it was more like glass in texture than the tough strong iron which it had been when fi made, and he was satisfied that it had only been subjected this extreme jarring action for a few months, and had not be otherwise employed. And further, it may be mentioned as circumstance of common occurrence that the porter-bars that a attached to the blooms whilst under the forge hammer, becam so brittle with the constant violent jarring to which they a

it they break in two after a very moderate amount
these instances there appears to have been no cause
ng or concussion to produce the change, as the iron-
d to little strain in proportion to its strength; and
y be observed of several of the instances mentioned
e of which the wrought iron arms of a fly-wheel
oose in the cast-iron rim, and broke off quite short
d and continued violent shocks caused by the cam
helve, although the iron was of the toughest des-
nally.

y Axles there can be no doubt that the same action
· concussion is in force, and may produce correspond-
on the strength of the iron; and that point at the
wheel where the effect of the jarring is concentrated
sensibly changed. The action of bending a piece of
ds and forwards will, doubtless, result in its fracture
est point, if it be carried on long enough; and it
essary, therefore, with a given weight of material in
proportion the strength at every point of its length,
y be capable of resisting the breaking force equally
the strength being proportioned so as to cause it to
ormly as possible at every point.

roportioned Axle, which was comparatively unyielding
e, would be more affected, both by the bending and
s at that point where the Axle is held fast in the
wheel, which is a mass acting as an anvil to break it
tendency to break at that point having been, of
vated by the obsolete practice of the Axle having a
der of considerable size at the boss of the wheel,
he present usual plan of making the least possible
the diameter of the Axle at that part for the purpose,
taper countersunk into the wheel.

iously, very desirable that every opportunity should
those who are practically engaged in the working of

Railways to investigate the facts connected with the failures o Axles in process of working, as detached experiments, howeve carefully and impartially conducted, cannot faithfully represen or afford results corresponding to the effects of the various strain and forces to which Axles are subjected whilst working on Railway.

The CHAIRMAN observed, that at the first discussion o this subject he took the liberty of drawing the attention of th members to the extreme care that was necessary in coming t any conclusion as to a molecular change in the constitution o wrought iron. He thought that there were a number of fact and statements on record which appeared to render i extremely probable that some change did take place in iron These proofs were now multiplied in number, but he though were not much increased in pointedness, if he excepted th experiment with the chain, which was the most striking an marked instance of which he had yet heard. Hence the must conceive that a change takes place in iron if subject t vibration; but an investigation into the precise cause of th change would require more time and care than could a present be devoted to it. He might remark, that since thei last meeting he had turned his attention to ascertain, i possible, whether any real difference exists in the molecula arrangement of the material or structure of a piece of iro called crystalline, and a piece of iron called fibrous; and fo this purpose he had examined them under a powerful micro-scope, and it would, probably, surprise the members to know that no real difference could be perceived, and that if he had not previously seen with the naked eye the specimens called

crystalline, he should not have been able to
he one from the other in the microscope. The
n he could select of the kind called fibrous,
the naked eye an arrangement of dark and light
light lines composing the apparent fibre were,
act, as crystalline as the other kind of iron, and,
wever fibrous it might appear, it was essentially
mass. Even in a piece of iron, with large facets,
red extremely crystalline, when one of the
examined, it gave much the same appearance
icroscope as a fibrous surface gives to the naked
it would appear to consist of bundles of fibres
ugh at certain angles, just as slate was observed
ries to break in particular rhomboidal forms.
instance of slate, there was nothing fibrous or
but owing to the peculiar arrangement of the
exhibited on a large scale something resembling
nces to be observed in iron—like fibres being
gh in particular planes.

ed to him that the fracture taking place in an
cular points, might be illustrated by reference to
ing thrown into vibration. There were certain
string called nodes where no motion took place,
action on the one side neutralises the action on
e particles at the nodes have consequently double
orm, being pulled in opposite directions at the
hence what might be called the nodes in the axle
action upon them, and this might induce a
appearance, although it might not cause much
e structure of the iron. It appeared to him a matter
difficulty to conceive a change going on in the
iron, because it would involve a change from one

kind of crystalline structure to another, which was next to a impossibility. He could imagine a number of particles unde the influence of vibration jostling the mass into particula forms, and become fibrous; yet, when they examined mo fibrous iron, they would find it already crystalline, whic involved the necessity of the molecules leaving one form crystal and taking another. It would be well for the mem bers to communicate to the Institution any well-authenticate facts of crystallization of iron, because nothing could have s important a bearing on the structure of Railway Axles as th means of tracing fractures to their real cause. Perhaps their next meeting he might have the pleasure of exhibitin to the members certain microscopic results, but as yet he ha not given the subject sufficient consideration to justify him i doing so.

Mr. Adams thought that the appearance called crystallin was caused by nothing more or less than a bundle of fibre consisting of many small crystals being sheared off squar forming one face.

Mr. H. Smith inquired whether the Chairman thoug there was any difference of strength produced. If they too the case of the common gag to the helve, or the prop th was placed under it, they found it became crystalline in th course of time and very brittle, though quite fibrous at firs So also in the case of the chains on inclined planes, the broke very soon. He should like to know whether crystallize iron was not weaker than fibrous.

Mr. McConnell thought it was so. Whenever iron w subjected to a jar, the fracture was square across, and seemed as if the whole structure of the iron became britt like glass. For in the instance he had mentioned of th chain sling, the iron was so brittle that a small tap of a hamme

would have broken it; hence, it must be obvious that whatever might be said as to the relative strength of fibrous and crystalline iron there was a striking difference between tough and brittle. He spoke then guardedly, because, from what he had seen of the appearance of iron under the microscope, he was induced to think that the word fibrous, which they had hitherto applied to the structure of iron, was a misnomer, if applied in the ordinary English acceptation of the term. That however an alteration did take place in the quality or condition of iron was manifest, from a great abundance of evidence; and he thought it would be a decided improvement if they adopted some other word which would express the same quality or condition of iron in its tough state: yet it was clear that a change did take place, making that which was originally tough quite brittle. The effect on a Railway Axle had been already explained by the instance of a string in vibration. When the axle was at work a node was created at the back of the wheel at each end, and it would be found that although it broke off short at the back of the wheel, yet in the centre it remained quite tough, as if the vibratory wave had passed freely through it. He should be glad to see the matter further investigated, as the subject was one of great importance, and at some future meeting he hoped to be prepared with some further information on the subject.

The Chairman remarked, that the question of comparative strength was one of great importance; but it must be borne in mind that there was great difference between the two strains of pressure and percussion; and he doubted whether highly crystalline iron was much weaker than iron which was highly fibrous. In the course of the building of the Britannia Tubular Bridge, his attention was called by his assistant Mr. Clark, to a series of bad plates which had been delivered. Instead of being fibrous boiler plates, they

were short grained and brittle; and this, in so large structure, was regarded as a serious objection to them accordingly it was decided to remove them from the botto of the beam or tube to the top, as in that situation the would be subject to compression instead of tension. He (t CHAIRMAN) thought it right to test the tensile strength those plates, and accordingly they had slips cut from t respective plates, and very much to their surprise the crysta line plates were much the strongest; for the average streng of the fibrous plates was 18 tons to the square inch, and a great many instances it ranged as low as 16 tons, whilst th crystalline plates averaged a strength of 21 tons, thoug they could hardly punch the holes in them, which was a goo test as to the quality of the plates. Hence they came to th conclusion, that what is called crystalline iron is capable of greater or at least as great a steady tensile strain as fibro iron, and that it does not appear less suitable than fibro iron for an erection of the character in which they we engaged. At the same time he thought it would have bee objectionable to have put the crystalline plates at the botto of the tube, because the trains were producing continu vibration; and the two strains—the one under vibration, an the other under steady weight—were very different in the character, and in their effect on iron. The mode of testin the plates at the bridge was by a very direct means, an therefore the results might be relied on with great confidenc They were tested by actual weights suspended direct from th plates themselves, and the strain was not put on by an machine, such as the hydraulic press, or by levers, where th fulcrum was liable to alter a little, causing a material differ ence in the leverage; and there was a considerable amoun of friction to interfere with the correct result. This woul account in some measure for the great discrepancy whic

prevailed in the results of former experiments with reference to the strength of iron during the last twenty years. Some had thought that the ultimate strength was 24 tons per square inch, but he was satisfied that in no well-conducted experiment would it be found to exceed 21 tons; and he felt that they could not safely rely upon a greater strength than 16 or 18 tons for practical purposes.

Mr. Slate enquired whether, when the Chairman spoke of 16 or 18 tons being the ultimate limit of elasticity, he meant would it fracture at that point.

The Chairman believed that fracture took place in every instance.

Mr. Slate said, he had, with some others, made some experiments on the strength of iron bars, and had minutely tested their elastic power. The result he had arrived at was that after the elastic point was once passed, time became a most important element in the fracture, and the breaking point would depend upon the rapidity with which the weight was put on. In some bars of the best quality of iron, 9 inches by 1 inch, the ultimate strength was 17½ tons per inch, but the permanent stretching began at about 8 tons per inch, and if that strain had been long enough continued, he considered the bar would have broken with it.

The Chairman observed, that according to the experiments made by Professor Barlow, the permanent stretching began at 8 or 10 tons per inch, and the bar never came back again to its original length after that limit of strain was passed. It must be borne in mind that the section of the bar was diminishing, and its density increasing during the stretching.

Mr. Walker observed, that in some experiments he had tried, it was found that 28 tons per inch was the ultimate pressure borne by bar iron, and in some cases it went up as high as 32 tons before breaking, but in these cases the weights had been applied very quickly.

The CHAIRMAN concurred in the opinion that time was a very important element in experiments of this nature.

MR. SLATE observed, that the same remark was applicable to cast iron.

MR. COWPER believed that the point at which the elasticity of iron was overcome and permanent stretching commenced might be measured at 8 tons per square inch, or by a fine micrometer, at 7½ tons; although by measuring more roughly with beam compasses, it had been stated so high as 10 tons. A bar 3⅝ inch square and 7 feet 6 inches long, bore 27 tons per square inch before it broke, and it was then extended in length 5 inches; the elasticity of that bar, after being permanently extended upwards of 3 inches, was as nearly as possible the same as it was at first before permanent extension had commenced, it was stretched one-eighth of an inch by the same increase of strain in both cases, and returned completely.

MR. SLATE doubted the accuracy of this principle.

The CHAIRMAN observed, that MR. COWPER meant, that although the iron was permanently extended, the cohesion among the particles was not so altered as to interfere with the law of its elasticity. The iron itself was not crippled, though the area might be altered; hence the law of elasticity was not altered, and the constitution of the iron itself was not deteriorated.

MR. ROBINSON said, he considered there was an advantage in making experiments with the hydraulic press, because it afforded a good means of detecting the stretching—immediately that extension took place the pump handle began to move faster. It was found in practice, that the moment they got beyond the elastic strain in a bar of iron it became deteriorated; and they never considered it capable of bearing again with safety unless it came back to the starting point.

AIRMAN did not mean to condemn the use of the
gether, but he thought a little want of accuracy
created by the use of it, for he thought it quite
some better means than the pump handle might be
and was in fact in daily use for ascertaining the
of the iron. Even a little leakage, or an extension
ar, would detract from the accuracy of the experi-
nd in the complicated pump apparatus there was a
al of friction. The pump might be out of order,
ce it was a matter of importance to use that mode of
which was not liable to go wrong, although the use of
weight might be the most troublesome.

ROBINSON said, he thought no bar was capable of
more than 14 or 15 tons per inch, but it was easy
in the reason why some had stated the results of
ents to range as low as 8 or 9 tons. The accuracy of
experiments depended on keeping the line of strain
axis of the bar, and in proportion to negligence
particular would they fail in obtaining the true
At the same time he thought it necessary that
experiments should be conducted on as accurate a
possible before they attempted to decide a point of
portance.

CHAIRMAN observed, that some experiments had been
y Mr. Edwin Clark, with iron bars, about 3 feet
d 1½ inch square. In order to discover the ultimate
of wrought iron he put weights upon the centre of
, but the deflection was so great that they bent down
the supports and the experiment was spoiled.
ingly he adopted this ingenious mode of ascertaining
nt; he took two bars perfectly similar, heated them in
ce, and allowed one to cool in a straight position ; the
was bent hot into a curve of 5 inches in 3 feet, and

then allowed to cool in that form. When both bars were cold he commenced experimenting with the plain straight bar and that bent very readily. But before he began to experiment on the bent bar he straightened it cold, and by so doing he brought the particles of the under side of the bar into a state of tension, or in other words into the condition of a tension bar, and the bar broke with very little deflection, but the strength increased materially.

The adjourned discussion on Railway Springs was introduced by reading the following additional paper, by Mr. W. A. Adams, of Birmingham :—

ON RAILWAY CARRIAGE AND WAGGON SPRINGS.

In the paper read at the last meeting, the writer brought before the Institution some Experiments on the relative qualities of Spring-steel, manufactured from English and from Swedish iron, and gave a description of the different constructions of Bearing and Buffer Springs, making a comparison between the Laminated Buffer Springs and the various kinds of External Cylinder and Piston Buffers.

An investigation was also given of the principles for regulating the form and thickness of the plates of the ordinary Laminated Springs, and the writer endeavoured to illustrate that the true and correct form for a Laminated Spring is a triangle tapering at a uniform rate from the centre to each end; and, further, that the Spring should not be weakened in the centre by a bolt or rivet-hole. He intimated his intention of preparing a Laminated Bearing Spring with Axle-box and adjustments complete according to these principles, and thus endeavour to produce the same results as in the ordinary Laminated Spring with the smallest amount of material.

Fig 11, Plate 7, represents a spring and adjustments of the following dimensions, which has been made according to the

above principles, and is laid before the present meeting:—

Length	2 ft. 8 in.
Camber	6 in.
Width	3 in.
Thickness in centre	$3\frac{7}{8}$ in.

Consisting of 10 plates $\frac{5}{16}$ inch thick, and 2 plates $\frac{3}{8}$ inch thick.

The weight of the spring, exclusive of the hoop, is 59 lbs.

This spring is very nearly a triangle, the base being but $\frac{1}{4}$ inch wide. To ensure the correct triangular form, the plates are cut to the correct lengths, as shown in Figure 10, and afterwards cambered.

In this spring there is no rivet or bolt-hole, the plates being held together by the clip A. The clip is rounded at the top and bottom, as shown in the section Figure 12, and the spring is therefore confined at the extreme centre only.

To prevent the plates sliding one past the others they are studded one into the other at the centre, as shown at B, Figure 12. To prevent the spring sliding from the hoop, a set screw C, Figures 11 and 12, is fixed in the bottom of the clip, the point of the set screw fitting a countersink in the bottom plate. The clip or saddle A is broad at the base to enable it to rest conveniently on the sides of the Axle-box, in the manner of an ordinary spring hoop, without interfering at all with the grease chamber.

The deflections of the above Spring are by actual experiment,

$\frac{1}{2}$ ton weight	$\frac{1}{2}$ inch deflection.
1 "	1 "
$1\frac{1}{2}$ "	$1\frac{1}{2}$ "
2 "	2 "
3 "	3 "
4 "	4 "

No permanent set in this experiment.

The smaller improved spring exhibited to the meeting, is of th following dimensions:—

Length	2 ft. 6 in.
Camber	5 in.
Width	3 in.
Thickness in centre	$3\frac{1}{2}$ in.

Consisting of ten plates $\frac{5}{16}$, and one plate $\frac{3}{8}$ inch thick.

The weight of the spring exclusive of the hoop is 48lbs.

The deflections by experiment are—

$\frac{1}{2}$ ton weight	$\frac{7}{16}$ inch deflection.
1 "	$\frac{7}{8}$ "
$1\frac{1}{2}$ "	$1\frac{7}{16}$ "
2 "	$1\frac{3}{4}$ "
3 "	$2\frac{5}{8}$ "
4 "	$3\frac{1}{2}$ "

No permanent set in this experiment. This spring is som what too rigid, and would do better with one plate less, reducin the weight to about 44 lbs.

COMPARATIVE TABLE OF DEFLECTIONS.

Strain on each Spring.	Thick Plate Spring Weighing 40 lbs.	Ordinary Spring Weighing 93 lbs.	New Spring Weighing 59 lbs.	New Spring Weighing 48 l
Tons.	Inches.	Inches.	Inches.	Inches.
$\frac{1}{2}$	—	—	$\frac{1}{2}$	$\frac{7}{16}$
1	$\frac{3}{8}$	$\frac{7}{8}$	1	$\frac{7}{8}$
$1\frac{1}{2}$	—	—	$1\frac{1}{2}$	$1\frac{7}{16}$
2	$\frac{3}{4}$	2	2	$1\frac{3}{4}$
3	$1\frac{1}{8}$	$3\frac{1}{4}$	3	$2\frac{5}{8}$
4	—	—	4	$3\frac{1}{2}$

By reference to this comparative table, showing the exper ments with the spring in ordinary use, described in the forme paper, it will be noted that the results are nearly the same a those of the Improved Springs now described, but with th

that the deflections of the Ordinary Spring are eased ratio, but with the Improved Springs the re in a uniform ratio.

ore appears that with a Spring weighing about 44 to same results can be obtained as with the Ordinary gon Springs, which weigh on the average 93 lbs.

en is exhibited to the meeting of the Ordinary Bearing Axle-box and adjustments and also the Improved Axle-box and adjustments. The adjustments of the pring weigh 7 lbs., and of the Improved Spring 5 lbs. ntages of the Improved Spring are presumed to be, uch as from the correct theoretical form and the the centre rivet or bolt-hole, every particle of the doing equal duty, the Spring will be more lasting; at from the reduction of material the first cost will ably lessened.

AMS briefly explained the Drawings, and the Speci- he Springs exhibited to the meeting; and added, g taken 2 tons as the full load on each spring, he voured to realize the full extent of action with the mount of material.

IAIRMAN observed, that he thought the proposed a decided improvement in the form of the spring, ng a hole through the centre. In the Ordinary centre portion was inactive, and the remainder really useful.

RIGHT said, the hole in the centre did not appear to at objection, and the only advantage in the proposed nsisted in it being much lighter than those ordinarily

in use ; but he thought the principle of all that kind springs, was wrong in having so much camber.

The CHAIRMAN said, it appeared to him to be intended a re-production of the advantages of other springs, with le weight and material ; and it was certainly incorrect to put hole in the centre of a girder, which was to carry a weig in the centre.

MR. WRIGHT thought the Long Flat Springs were the be such as were used in carriages, and that they prevented t axles from breaking, as they did with the other springs us in waggons, and they would not deflect too much, not mo than 2 or 2½ inches.

MR. McCONNELL thought the Carriage Springs were o useful whilst the tension of the load was not enough to bri them flat, but beyond that they would become useless a quite rigid; and with reference to Waggon Springs, thought the tension would be too great to make the princi applicable.

MR. WRIGHT suggested a Tension Spring, with a lo shackle at each end, on the same principle as some ordina Waggon Springs were hung.

MR. ADAMS observed, that the form of spring he suggest was very even in its work and uniform in its deflect throughout. With each additional 5 cwt. of load it su ¼ inch ; and with 3 tons upon it the spring was quite as ea because there was still the same deflection of ¼ inch for e 5 cwt., as with the lighter load.

The CHAIRMAN considered it an important advantage t this uniformity of deflection or elasticity, extended throu out the entire space.

MR. SMITH thought it a decided improvement to get ri the hole through the centre, because it enabled them to m use of the whole of the steel in the spring to the very cen

Mr. Ross did not see an advantage in the nibs in the centre of the spring, instead of a rivet, and thought they would weaken the spring in the centre as much as the rivet-hole. He suggested the introduction of a solid block of ash or oak, for the bearing of the spring in the centre, as he considered there was great benefit resulting from that plan. For three or four years past they had introduced wooden blocks into Buffer Springs, with decided advantage.

Mr. H. Wright said, in practice, they seldom found a spring break in the centre in the case of Carriage Springs, owing to the long bearing on a wooden block; but Engine Springs were liable to break in the centre, where there was only a short bearing, without wood in the centre. But in the Carriage Springs the material in the centre was certainly inactive, and it was an improvement to save that inactive material.

Mr. Adams remarked, that his object was to improve the present Waggon Spring, by combining the best action of that kind of spring with the least amount of material; and with regard to the plates being nibbed into each other in the centre, he thought that could not weaken them at all, as there was not any portion of the material removed, as was the case with the rivet-hole; but, on the contrary, from the sectional form of the nib, the strength of the plates was perhaps rather increased than diminished in the centre.

The Chairman observed, that it was desirable to have great elasticity in the spring with a heavy load, and less elasticity with a light load; but springs generally were the reverse of this, and it was an important advantage in the proposed spring, that it was equally elastic with a heavy load as with a light one. In railway waggons it was impossible to keep the loads so uniformly distributed as in carriages.

Mr. Wright thought that the Tension Spring would yield equally at every point of its elasticity.

Mr. McConnell observed, that it would diminish in elasticity as the load increased, because it would become at last absolutely rigid, and could not yield any further.

Mr. Slate considered that the construction of the Tension Carriage Spring was very unmechanical; the strain of the spring was carried through a curve, and though it might do extremely well with a light load, yet when it was applied to waggons varying in their load from 3 to 10 tons, the limits of tension would be exceeded, and between the ends of the scroll irons it would be perfectly rigid. He thought no strength of material that could be put in the tie would be equivalent to support a heavy load in that particular direction, because it must either stretch, or if not elastic must certainly break. Besides, he considered there was an immense strain upon the scroll iron, and the form itself was objectionable, however well the curved form might be in appearance.

Mr. Adams explained by the drawing that the straightening of the top plate, as the spring deflected compensated for the deflection of the shackle, and prevented any undue strain within the limits of load that kind of spring was subjected to in passenger carriages; and the action of the spring was materially assisted by the form in which the plates were set in making the spring, the set being all given at the centre of the plates, thus  instead of the plates being bent into a uniform curve throughout, thus 

Mr. DeBergue then read the following observations on the India-rubber Buffers, in reference to the notice of them in the paper read at the last meeting; the Chairman remarking first, that it was irregular for a paper to be read upon another paper, and could only be permitted as a special exception in the present case, and not as a precedent.

In reference to the observation that the sustaining power of the India-rubber Buffers is too great, and that in the event of a collision the train might collapse before this was fully developed

would observe—that the most effective buffers in the collision will be those which will oppose the greatest resistance moving through the greatest space, provided num resisting force should not exceed the pressure be sustained by the under frames of the waggons ury. Now the maximum sustaining power of a pair dia-rubber Buffers does not exceed 20 tons, and as everal thousand sets of them in use, many of which es been driven quite home without the waggons being follows that their resisting power does not exceed it, and that they must consequently be much more the event of a collision than any other buffers having oke and only one-third of the resisting power.

ust be borne in mind that buffers are not solely re-cases of collision, they are more generally serviceable e slighter concussions in stopping and starting trains, ngs and warehouses; and in order that they should te to this service, their resisting force must be com-ery small at the commencement of the stroke; no roduced combines these properties so perfectly as the India-rubber, indeed it is so easily acted upon at the nt of the stroke that it has been found advisable to four rings in each buffer to the extent of one inch roke commences.

mense sustaining power of these buffers were objec-ould be reduced to any required amount, simply by he diameter and thickness of the rings, which would the cost—but, in the opinion of the writer, that stroying one of the most valuable properties of these

ison has been made between the relative proportions esistance of a pair of buffers of 12 inches stroke with y Laminated Spring, and a pair of the India-rubber fers; but, in the writer's opinion, the calculations are

incorrect. It has been assumed that the India-rubber Buffers have only $1\frac{1}{2}$ inch stroke with a final resistance of 3 tons—say 3 tons $\times$ $1\frac{1}{2}$ inches $=$ $4\frac{1}{2}$ effective resistance of a pair of India-rubber Buffers. Then 12 inches is given as the stroke of the Laminated Spring with $2\frac{3}{4}$ tons, which would make $2\frac{3}{4}$ tons $\times$ 12 inches $=$ 33 effective resistance, the proportion being $4\frac{1}{2}$ to 33, or 1 to $7\frac{1}{3}$.

But as regards the India-rubber Buffers, the length of stroke is exactly 3 inches, and the maximum resistance 20 tons for a pair; and as this large amount of resistance is mainly accumulated towards the end of the stroke (as will be seen from a statement of experiments annexed), it would not be correct to take the half of that as the average resisting power; but it is presumed that it will be keeping within the limits to take only one-quarter of the maximum resistance—say 5 tons, as the average resisting power for a pair of buffers, thus—5 tons $\times$ 3 inches $=$ 15 effective resistance.

With regard to the Laminated Spring—$2\frac{3}{4}$ tons is given as the resisting power of the spring for the pair of buffers with 12 inches of action; but this $2\frac{3}{4}$ tons is the *maximum* resistance of the spring deflected to a straight line, and being a steel spring, and its resistance not increasing in the same compound ratio as the India-rubber, nearly half its maximum power should be allowed as the average resistance throughout the stroke—say $1\frac{3}{8}$ ton $\times$ 12 inches $=$ $16\frac{1}{2}$ effective resistance; thus it appears that the proportionate effective resisting force between a pair of the India-rubber 3 inches stroke Waggon Buffers, and a pair of 12 inches stroke ordinary Laminated Spring Buffers, is as 15 to $16\frac{1}{2}$, instead of being as 1 to $7\frac{1}{3}$.

It may be here observed that the India-rubber Buffers are not limited to 3 inches stroke; some are made $4\frac{1}{2}$ inches, and some with 6 inches stroke for Passenger carriages, and their resisting power is proportionately increased, but this incurs additional expense, which is a matter of no small consideration in the present times, and it is found from lengthened practice that the 3

inches stroke Buffers are quite sufficient for all classes of Goods Waggons, and even for Cattle Trucks, Luggage Vans, &c. The size of the India-rubber rings in these 3 inches stroke Buffers is $5\frac{1}{4}$ inch diameter and $1\frac{1}{2}$ inch thick.

With respect to the durability of the Vulcanised India-rubber, a reference has been made to elastic bands for papers that have become completely rotten; but it will be sufficient to state the fact that a great quantity of these bands have been made that were never "vulcanised" at all, and were manufactured under an independent patent for "converting," but they were sold by the same parties, and the public did not know any difference. The India-rubber rings used in the Buffers are all Vulcanised, and the writer has examined many of them that have been at work for several years, and he has not yet met with a single instance of a bad one.

It has been objected to the External Cylinder Buffers, that the piston or plunger is guided through too short a space, which makes it more liable to break the cylinder in the event of an oblique blow; but it should be observed that this defect is obviated in the India-rubber Buffer, where the length of the bearing extends from the mouth of the cylinder to the end of the boss on the base plate, the spindle being fitted so as to form a solid body with the plunger. The India-rubber Buffer is superior, in the writer's opinion, to the other External Buffers, in efficiency and durability, whilst equally compact and economical, as the resistance begins very gradually at the first part of the stroke, and increases to a great power at the latter part, without coming to a dead stop at a moderate pressure, as in the other Buffers; the pressure being spread uniformly over the whole surface of the base plate, which is better adapted to preserve the waggon frame from injury, and the elastic material is not liable to break, as steel whether in the form of a spiral or otherwise.

The following Table shows the actual compression of one of these India-rubber Waggon Buffers of 3-inch stroke, with each

increase of pressure from $\frac{1}{4}$ ton up to 10 tons, tried with g
accuracy in a machine made for the purpose.

Pressure in Tons.	Amount of Action in Inches.
$\frac{1}{4}$	·125
$\frac{1}{2}$	·625
$\frac{3}{4}$	1·063
1	1·344
$1\frac{1}{4}$	1·694
$1\frac{1}{2}$	1·750
$1\frac{3}{4}$	1·906
2	2·031
$2\frac{1}{2}$	2·219
3	2·375
4	2·563
5	2·750
6	2·813
7	2·875
8	2·938
9	2·969
10	3·000

Mr. H. Wright observed, that he had used the India-rubber Buffers very extensively in waggons, but not in carriages, and he considered them to act efficiently.

Mr. Henson said he was not able to speak from his own experience of the India-rubber Buffers, as he had only had five sets of them in use; but he thought the material was not durable, as he had seen specimens of the Vulcanised India-rubber which had quite perished in the packing of the Air-cylinder Buffers.

Mr. Robinson enquired whether there had been any oil in contact with the vulcanised India-rubber in those specimens, as he understood it would not stand the action of oil; but Mr. Henson said he believed it had been kept free from oil.

Mr. H. Wright said, that on the North Staffordshire Railway all the waggons were made with the India-rubber Buffers, and he had not found the material fail in any instances: the only failure of the Buffers had been in the cast-iron casings, which had broken at the flange of the cylinder in many instances; but they were easily repaired, and the risk of breaking could be prevented by an alteration in the castings.

Mr. De Bergue explained, that the objection had been obviated by an improved form of the castings, and showed a drawing of the present construction of the Buffer. (Fig. 13, Plate 7.)

Mr. Adams remarked, that his objection to the India-rubber Buffer consisted in the circumstance, that the length of action was very short for the extent of resistance that was ordinarily called forth in Buffer Springs; and he should prefer a less resisting power continued through a greater space.

Mr. McConnell observed, that in that case a Laminated Buffer Spring would be required, which brought them a question of greater cost.

Mr. Adams replied, that it was a mistake to suppose t
the Laminated Buffer Springs would be much more expen
than the External Buffers, such as the India-rubber Buff
and he considered that they would cost but little more, no
much as 25 per cent. more including the buffer rods c
plete, and that the increased cost would be well laid ou
Laminated Springs, being the best in the end.

The Chairman observed, it was an important circumsta
if the expense of employing Laminated Springs was re
not greater, as their advantage was obvious from the m
greater length of action.

Mr. Wright thought that the increase of cost would
considerably greater, and that it was a question of he
expense on a large number of waggons. He considered
the repairs would form an expensive item in the Lamin
Springs, as they would be so much knocked about in wagg

Mr. Ramsbottom remarked, that it was important to h
a Draw Spring as well as a Buffer Spring in all waggons,
the Laminated Spring might be made to serve both purpo

Mr. McConnell observed, that they were much indebte
Mr. Adams for his communication on this important subj
and proposed a vote of thanks to him, which was passed.

In consequence of the absence of Mr. Wm. Smith,
further consideration of his paper on the Engines of the So
Staffordshire Iron District, was adjourned.

The following paper, by Mr. George Heaton, of Birmi
ham, was then read,

ON THE IMPORTANCE OF MAKING A COMPENSATI FOR THE PULL OF THE AIR PUMP BUCKET THE CONDENSING STEAM ENGINE.

In the year 1844, the author of the present paper was emplo
to inspect and ascertain the cause of the irregular motion
inefficient performance of a Steam Engine and Mill used for

of Grinding Corn. The Mill had nine pair of Corn ive on one and four on the other side of the driving The bottom of the Corn Spindles frequently moved and the whole framing which carried them, those most dis- the power having the greatest strain, frequently moving of an inch, and the end of the horizontal Shaft which e Corn Spindles partaking of the same movement and much heated with its work, and the Teeth of the uch worn on both sides.

ll work was very good and substantial, and had been about s at work. The Steam Engine with Cylinder 40 inch stroke of Piston 6 feet, Air Pump 26½ inches diameter, t stroke, was altogether a strong well-built Engine; the essure was about 6 lbs. per inch, and the Engine was work- ¾ strokes per minute, but if attempted to be run faster nore irregular motion was produced. The Governor was ith gear at the top of a vertical shaft 14 feet long, and the the Governor frequently moved in and out 4 or 5 inches ne stroke of the Engine. When running at the speed of kes per minute, the Governor Rod at the throttle valve quently moved ¾ to 1 inch during each stroke of the he greatest opening of the valve being invariably at the he pull of the Air Pump Bucket; there was a great in the distance the rod moved each stroke, moving the every 4th or 5th stroke. The Engine appeared to have lead, for the reversing blow was struck before the crank t the centre. The time of opening the valves was therefore ffecting a saving of steam and requiring the Governor Rod rtened more than 1 inch, (the throttle valve lever being long); however the irregular motion continued, and the vith nine pair of Stones appeared to have too much work.

ngine was constructed according to the general practice, about an equal weight hanging upon each end of the ne weights of the different parts were stated to be as —

AT THE CRANK END.	T.	C.	Q.	LB.
Connecting Rod and Block at the Top .	1	11	3	14
4 Brasses	0	0	2	0
Cold Water Pump Bucket and Rod . .	0	2	2	0
Crank and Pin	0	14	3	0
Feed Pump, Plunger and Rod	0	2	0	0
	2	11	2	14
Deduct for Weight of Crank balanced on the main Shaft	0	9	0	0
Total Weight	2	2	2	14

AT THE CYLINDER END.	T.	C.	Q.	LB.
Piston Rod	0	4	1	19
Piston and Ring	0	14	1	0
Pins, Gibs, and Cotters for ditto . . .	0	1	0	21
Parallel Motion	0	11	3	0
Cap and Gudgeon to Piston Rod . . .	0	4	0	0
Plug Rod	0	3	2	0
Air Pump Bucket	0	4	2	0
Total Weight	2	3	2	12

consequently the weights at each end of the Beam were balanced within 1 cwt.

The following alteration was then effected in the Engine:—

A weight was fixed at the crank end of the Engine Beam, to assist in the pull of the Air Pump Bucket, and retard the speed of the Engine on the opposite side of the stroke; this weight was 19 cwt. 3 qrs. 14 lbs., and from its position it was equivalent to about one-half the pull of the bucket, considering the average pull through the whole lift. The Engine Beam was double, and the balance weight was fixed between the two sides of the beam; also the Governor was altered to be driven by a band instead of

the former gear and long shaft. The Engine was then set to run at 19½ strokes per minute, the speed required by the Company for its work, so as to drive the stones at about 128 revolutions per minute, instead of about 117, the former speed; the Corn Spindles then ran quite steady, the Necks of the horizontal shaft kept cool, the dust remained on the back part of the Teeth of the driving wheels, and the Governor Rod remained steady for a long time together, without anything else being done to either the Engine or Mill. Since that time the Company have added five pair more Corn Stones to that end of the Shaft the five pair are at, and they run equally steady with the others. The Engine appears now to drive 13 pair of Stones with greater ease and freedom than it drove 8 pair before the balance weight was added, and the repairs have been considerably diminished in the same space of time. Believing that the pull of the Air Pump does not generally receive the consideration it requires in either Stationary or Marine Engines, is the writer's apology for bringing this paper before the Meeting.

The CHAIRMAN in moving the thanks of the meeting to MR. HEATON, said, such subjects were of so much importance that they could not too frequently be brought before the attention of Engineers. He trusted that the important statement in this paper had been made with great care, for it was surprising to hear of such great results flowing from such simple means. He should be glad if Engineers generally, would communicate all such results as occurred in their experience, because the collection of them would prove of great value.

A vote of thanks having been passed to the writer, Mr. Heaton gave some further explanations of the subject of the paper, and observed, that the engine referred to, was working at the Old Union Mill, at Birmingham.

The Chairman then announced that the Ballot lists had been opened by the Committee appointed for the purpose, and the following new members, &c., had been elected :—

Members.

Robert Bowman, Wolverhampton,
Josiah Evans, Warrington,
H. H. Henson, London.

Graduate.

Lewis Roughton, London.

Honorary Member.

Edwin Gwyther, Birmingham.

The Chairman remarked that he was glad to see so many of the members present, as it showed they felt an interest in the Institution, and he hoped that they should have an equally numerous attendance at their next meeting.

The meeting then terminated.

PROCEEDINGS.

24 July, 1850.

The usual **General Meeting** of the members was held at the House of the Institution, Newhall Street, Birmingham, on Wednesday, the 24th July, 1850; J. E. M'Connell, Esq., Vice-President, in the Chair.

In opening the proceedings, the Chairman regretted that, on this occasion of the first meeting of the members of the Institution in their new house, they had not the presence of Mr. Robert Stephenson, their respected President, who was prevented from attending the meeting in consequence of being engaged at the floating of the last tube of the Britannia Bridge.

The minutes of the last General Meeting were read by the Secretary, and confirmed.

The Chairman then said, he had the pleasure to announce to the members, that their President had given to the funds of the Institution the very handsome donation of £100, to mark his sense of the importance of the Institution; and never were their prospects and finances in so flourishing a state as at the present time. They were now in possession of rooms for the meeting of the members at any time they came, where they would always find their Secretary to receive them, and afford information and assistance with reference to the proceedings and objects of the Institution. He hoped that they would soon be able to add to the usefulness of the Institution by a

good mechanical and scientific library for referenc
would of course depend upon the contributions
desirable an object; they had already the nucleus o
and received the various engineering periodicals.
that great practical benefit would result from the i
amongst the members which the Institution was ca
afford. In conclusion, the Chairman proposed a vot
to the President for his handsome donation, which w

The Secretary then read the following pape
WILLIAM SMITH, of Dudley:—

ON THE CONDENSATION OF STEAM IN THE OF THE SOUTH STAFFORDSHIRE IRON AND THE IMPROVEMENTS TO BE EFFE THEM.

THE object of the present paper with the accompanyi
Indicator Diagrams, which have been taken from
engines by the author of the paper, is to shew the pr
ing condition of forty-eight of the largest class of
and blast engines in South Staffordshire, with some re
the practicability of improving them.

[*For the description of the Indicator Diagrams, see R General Meeting, January* 24, 1850, *in which a paper is included.*]

The general character of the Indicator Diagrams of t
of these engines, shews a considerable pressure of
tinued nearly uniform throughout the whole stroke of
and averaging about 12 lbs. per square inch above
phere in the forge and mill engines, and about 7 lbs.
inch in the blast engines; with a very defective va
mencing about the atmospheric line, and reaching
7 lbs. to 11 lbs. per square inch below the atmospher
of the stroke, the average vacuum being about 6½ lbs.

inch below the atmosphere throughout the stroke. Some of the Indicator Diagrams from blast engines shew a considerable expansive action, but not a good vacuum.

Fig. 12, Plate 8, shews the Indicator Diagram from a mill engine of 42 inch cylinder and 7 feet stroke, making 17 strokes per minute, which was working very imperfectly in the condensation of the steam, and has been improved to a remarkable extent, by an alteration made for the purpose of improving the vacuum, which has effected a very considerable saving in the consumption of fuel. This engine was working with 19½ lbs. pressure of steam at the beginning of the stroke, continued to 17½ lbs. pressure at the middle, and reduced to 6 lbs. per inch at the end of the stroke, by wire-drawing the steam without any cut off expansion valve; the average pressure being 16·37 lbs. per square inch throughout the stroke; the average vacuum was only 2·72 lbs. per square inch below the atmosphere, beginning a little above the atmospheric line, and reaching only 5 lbs. below the atmosphere at the end of the stroke. This performance being so bad it was considered necessary to examine the engine, and the cause was found to be from the valves, thoroughfares, and condenser being much too small for the proper proportion, the steam and eduction valves being only 7 inches diameter, and the thoroughfares of the same size; these were therefore removed and replaced by others, the steam valves being 10 inches diameter, and the eduction valves and thoroughfares 12 inches diameter, or three times the area of the original ones. The condenser was also nearly doubled in capacity by attaching a large vessel on the top of it, which made it rather larger than the regular proportion; the air pump was only 24 inches diameter, with half the stroke of the steam piston, or about ⅛th less contents than the regular proportion for the size of the cylinder, this was not altered, but there was an abundant supply of cold water for injection.

The result of the above alteration is shewn in the Fig.

12A., the steam pressure being 8 lbs. at the beginning, an reduced to about the atmosphere at the end of the stroke, th average being 5·40 lbs. instead of 16·37 lbs. per square inc pressure throughout the stroke; the vacuum commenced at 10 lbs. and ended at 11 lbs., the average being 10·15 lbs. instead 2·72 lbs. per square inch below the atmosphere throughout th stroke. The improvement in the vacuum amounts therefore a constant average pressure of 7·43 lbs. per square inch throug out the stroke; the total power of the engine as shewn by th first Diagram, was 19·09 lbs. per inch on the piston througho the stroke, being 190 Horse-power, consequently this improv ment of the vacuum amounted to 39 per cent. of the total pow of the Engine or 74 Horse-power.

The mode of effecting the above alterations is shown in Fig 12B and 12C, Plate 9. Fig. 12B, shews the engine before th alteration, the steam valves S, the eduction valves E, and th thoroughfares T being only 7 inches diameter. Fig. 12C shews th engine after the alteration, the steam valves S are increased 10 inches diameter, and the eduction valves E and thoroug fares T are 12 inches diameter; the new valves being so mu larger than the old ones, a different arrangement was required make room for them, the spindle of the lower steam valve bei carried up the side pipe, as shewn in Fig. 12C, and the upp eduction valve placed over the other side pipe, so that three of th valve spindles are worked at the upper steam chest, and one on at the lower.

The addition made to the condenser is shewn at C, whi was a circular vessel constructed of boiler plate, 3 feet 6 inch diameter, and 15 inches high, fixed on the top of the condens A further improvement was also made in the condenser, cleaning out the deposit of lime, and adding an internal inje tion pipe and rose P; there was no internal injection pi previously, but simply a hole in the side of the condenser, whe the Injection-cock A was fixed on, as shewn in Fig. 12

and consequently the injection water was much less efficient in condensing the steam, being poured into the condenser in a single stream instead of being scattered in a number of small jets from the rose end of the pipe.

The majority of engines in this district are similar in this respect, and the reason that has been given, is, that the rose is apt to get the holes choked up by deposit from the water, which is very much impregnated with lime. This is a matter requiring particular attention in this district, and cases have come under the writer's observation, where condensers were filled up by the deposit in the course of two or three years time, to such an extent, that the capacity was reduced fully one half, as well as the passage through the foot valve; it is a very hard calcareous deposit which adheres firmly to the cast iron, and requires considerable labour to cut it out, involving a serious stoppage of the engines, and they were consequently worked as long as possible before taking off the condenser cover to cut out the deposit, which increased to 7 inches thickness, and as much as half a ton weight in one engine.

Besides the very important saving effected by the greater power obtained from the steam, in consequence of the improvement of 39 per cent. in the vacuum, as described above, the engine has been found to do the work more regularly and satisfactorily since the alteration, than before; it was liable to be pulled up by any extra strain of the rolls, &c., whenever the piston was getting in want of repacking, the leakage of steam injuring the vacuum on account of the very deficient condensing power; but that has not occurred since the alteration was made.

The engine drives a merchant mill of 3 pair of rolls, a guide mill of 3 pair, 2 pair of forge rolls, a forge hammer, 2 shears, and a pump for draining the foundations. It was not stopped longer than three days to make the whole of the alterations described above.

Another similar Engine of the same size as the preceding,

(No. 17) was also examined, in consequence of the imper
in its condensing, and the valves and thoroughfares were
to be 10 inches diameter, but the valves had not sufficie
the eduction pipe to the condenser was 9 inches diamete
the condenser was 2 feet 4 inches diameter, and 4 feet 6
high; the eduction pipe was then removed and replaced w
12 inches diameter, also a large vessel was fixed on the top
condenser, which increased its capacity about one third.
lift of the valves was then increased from $1\frac{1}{8}$ inch to $2\frac{3}{8}$
and the result of the alteration was an improvement in the v
of from 1·50 lbs. to 7·97 lbs. per square inch below the
phere, or 6·47 lbs. per square inch increase of average p
throughout the stroke.

The saving of fuel from these alterations has not bee
ascertained, as the engines in both cases are worked from
of boilers which also supply steam to other engines upon
the load is very unequal, but the saving is admitted to
considerable, and in the case of No. 17, the proprietor
been enabled to use an inferior description of slack, and
throw off one boiler, with a fire grate about 7 feet square,
square yards of heated surface, without any diminution
power employed.

The aggregate power of the 45 mill, forge, and blast
from which the Indicator Diagrams are taken, is nominal
Horse-power, according to Boulton and Watt's proportions
cylinders, but by the calculation of the Indicator Diagra
total is 7819 Horse-power; the average vacuum obtained
present working of all the engines, is about 6 lbs. per inch
the atmosphere throughout the stroke, omitting from the
four, which are exceptions to the general run of these e
and the average vacuum obtained in the 6 expansive eng
which Indicator Diagrams are also given, is $10\frac{1}{2}$ lbs. p
below the atmosphere throughout the stroke. The loss of
from the imperfect vacuum in the former engines may th

he difference between these pressures, or $4\frac{1}{2}$ lbs. per pressure throughout the stroke, which amounts to ed Horse-power upon these engines, or in other litional power of 1930 Horse-power, or 25 per cent. wer might be obtained from the same expenditure consequently of fuel, if the vacuum were improved as good as the average of the 6 expansive engines, r inch throughout the stroke. This vacuum has been two engines, Nos. 12 and 17, which have been ore described, although in these engines the alteration ut only to a limited extent, and at a comparatively se; but if it were carried out efficiently by attaching r in addition to the alterations that have been made, r effect would be obtained by using the same volume nsively.

cases the expansive action is accomplished by the separate expansion valve in the steam pipe, which a cam, so as to cut off the steam at any portion of at may be desired, this valve opening and shutting ch double stroke of the engine; the steam and ves are worked by a common eccentric motion, the om valves opening and shutting together. But this ct mode of obtaining expansion, because the steam de pipe and the two steam chests expands after the is shut, and this steam forms a considerable propor- ntents of the cylinder.

efficient mode of applying expansive action, is by valve by a separate cam, so adjusted as to shut each t whatever point of the stroke may be desired, whilst valve is held open till the termination of the stroke; ans the full effect of the expansive action is obtained. ce in effect between these two modes of cutting off s shewn by the Diagrams Nos. 46 and 47, Plate 8. aken from a pair of blast engines working coupled

together, and with no difference between them except that in
46 the steam is cut off by a separate expansion valve in
steam pipe, and in No. 47 the valves are lifted by separate c

But independent of the loss sustained by not working ex
sively, the loss of power in the engines described being
Horse-power as shewn before, the annual loss in money by e
consumption of fuel in these engines, calculating 20 lbs. of
per hour, for one Horse-power, at a cost of 3s. per ton,
amount to £18,610, or £2 7s. 7d. per Horse-power per annum

The total power of the steam engines employed in the manu
ture of iron in this district, may be computed to be fully ten t
the nominal power above named; and the total annual loss to
proprietor from the causes described in the present paper,
be therefore taken in round numbers at £180,000 per an
as the more expansive engines described above, may be consid
a fair average of the engines in the district.

It has been generally considered hitherto, that the improve
of expansive action of steam was not applicable advantage
to the engines of this district, because of the small cost of
fuel employed; but this will be seen to be an erroneous
clusion from the actual results of the alterations described a
where the improvement was only effected in the vacuum, and
expansive principle was not carried out, which would
effected a still greater saving. The total quantity of fuel
sumed at present is so large, that although the price per t
insignificant, the total amount of saving effected by the
centage on the whole is very important.

In addition to the saving in cost of fuel consumed, a
important saving would also be effected in the tear and we
the boilers, which is fully in proportion to the extra fuel b
under them, and the repairing of which is invariably atte
with serious inconvenience and expense.

The description of boilers in general use in the district,
the further saving to be effected by improvements in their

d mode of setting, is also an important practical consideration, and it is intended to form the subject paper, to be laid before the Institution at a future

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IRMAN said, he believed the writer was quite within n he estimated the saving in fuel which might be hat district alone, at £180,000 per annum; nor was of importance in that light merely, because it was evail as a general rule, that the amount of destruchinery and boilers was nearly in proportion to the f fuel consumed. He had remarked at a former the practical importance of obtaining comparative complete as possible of the consumption of fuel, ly of working of the steam engines in the different the country, and he thought that all information of as of great practical value.

VMAN inquired whether, in most of the engines the proportions of Boulton and Watt were the Condenser?

SMITH replied, that speaking generally he believed e case, but the bad working of the Engines was or by the extraordinary pressure of the steam used. as, that engines intended and proportioned for 3 lbs. worked up to 12 or 16 lbs. per inch throughout the consequently, they were very imperfect in their ; as there was so much larger quantity of steam to ed at each stroke, when the cylinder full of high eam expanded down to the same pressure as the low eam.

Mr. Bowman observed, that this would seem to imply t the size of the condenser should be regulated by the press of the steam in the cylinder.

Mr. Cowper said, the pressure of the steam was certai a necessary element to be taken into consideration, as wel the size of the cylinder, in determining the size of the c denser. There was not only a greater quantity of steam condense when a higher pressure was employed, but als greater quantity of air to pump out at each stroke of the pump. He mentioned a case which came within his c observation in that district, where 18 lbs. steam was employ there was no barometer guage, but the parties were satis that they had a good vacuum; however, the fact was, that injection water was forced into the condenser by means o cistern at the top of the engine house, 22 feet in height.

Mr. Slate remarked, that he fully concurred in the res obtained by Mr. Smith, but feared they were so startling t there would be a disinclination to give them credence in district. It was highly important then that the truth of deductions should be practically admitted.

Mr. T. Thorneycroft, as an iron-master of the dist referred to, felt extremely obliged to the author of the pa for pointing out the means whereby any saving could effected, more especially at a time when, owing to the stat the trade, economy in the manufacture was so essential.

Mr. W. Smith said, it had often occurred to him, tha steam engine was like no other machine. A time-piece out of order, was sent back to the maker to be repaired, and the case of machines of other descriptions, if they did not their work well they were immediately stopped, because t wasted and injured the material upon which they w employed. But when the old steam engine, after 20 or

years' of hard labour, shewed some symptoms of disorder, it could not be stopped, so with an extra application of the coal shovel, and some hammering at the cotters, &c., it was set to work again, and with its powerful steam arm it wound round all the complicated machinery. This, however, was done at an enormous expense to the proprietor of the engine, and it would be much better if he were to renovate its constitution. He trusted that the exertions of the members of the Institution would have some influence in shewing to persons of the description referred to, the necessity of carrying out these things on more efficient principles than they had hitherto been conducted.

Mr. Bowman thought it a matter of great importance that the injection water should spread itself out amongst the whole quantity of steam immediately on its passage into the condenser, and the alteration made by Mr. Smith in the mode of injection was very advantageous.

Mr. Cowper observed, that they ought all to add their testimony to the value of the Indicator Figures produced by Mr. Smith, because they shewed the character of the engines much better than any judgment which could be formed with reference to them, inasmuch as it was the character of each engine written by itself, and could not be erroneous. He had not the slightest doubt, that a loss of £180,000 at least, as stated by Mr. Smith, was sustained in that district, because the mode of condensing ordinarily adopted was exceedingly defective. It had occurred to him many years ago, that a valve might be put at the side of the condenser, and connected with an injection pump, so that a gush of cold water might be injected at every stroke, at the very moment of the entrance of the steam into the condenser, and shut off again immediately, by which means the greatest possible use might be made of the injection water,

and the condensation of the steam effected with a small quantity of injection water.

He then explained the drawing of an improved injecti valve which he had constructed, and found to work very su cessfully ; the object was to maintain the full pressure of t water at the point of entrance into the condenser, and obtain a more efficient distribution of the jet of water witho danger of its getting choked. In Fig. 1, Plate 10, A is t condenser, B the eduction pipe, C the air pump, D the co water cistern in which they are immersed; E is the injecti valve, a conical valve rising a little above the bottom of t condenser, with a perforated cap below in the cold water cister this valve is lifted by the screwed rod F, and the admissi of the injection water can be regulated with the great accuracy by the screw. The water enters the condenser in fine sheet all round the valve, which strikes the sides of t condenser and fills the whole space with a fine spray ; he h ascertained this by trying the valve in a box similar to the co denser, but partially open, with a column of water of the sa pressure as the injection, and he found the distribution of t water was so perfect as to fill the box with a complete spray fog. There was also a different construction in the air-pun which he considered advantageous; the bottom dropped into well GG, in the bottom of the condenser, and the water ro up the space GG, when the air-pump bucket dipped into forming a water-valve instead of the ordinary foot-valve, an giving pressure enough to ensure the bucket-valve opening there was any obstruction.

Fig. 2, Plate 10, shews the indicator figure, taken from th engine when in full work, at 24 revolutions per minute, dri ing shafting and two fans, and amounting to 72¾ indicate Horse-power. Fig. 3, is the indicator figure of the san

part of the work was thrown off, amounting to
›wer; and Fig. 4, is the indicator figure for the
'our lines of shafting alone, without any work,
› 14 Horse-power, at the same speed of 24
›r minute. The Engine is high-pressure, expan-
lensing, and is one of a pair working coupled
re was originally in their place, a pair of high-
ines, non-expansive and non-condensing, and
ive economy of power effected by the present
great, that although the same boilers only are
2¼ to 2½ times the power obtained.

tor figures exhibited by Mr. Cowper to the
› drawn to the scale of 20 inches length of stroke,
r each lb. of pressure; and he begged to suggest
a convenient one to be adhered to, for indicator
led to be exhibited to the Institution.

: thought the plan of injection proposed by
was a very eligible one. With reference to the
ction of the water, he had experienced the diffi-
ne engines, of too much water being admitted by
cock, whenever the engines were working slowly,
ijection water to choke up the condenser and even
ie cylinder, and he had adopted a slide valve in
pipe, admitting only water enough at each stroke
for the condensation of the steam; the jet of
rown against a perforated distributing plate.

rman remarked that, there would be a tendency
' the injection pipe, as adopted by Mr. Smith, to
›d up.

er observed that, in the plan he had described,
was quite obviated, as in the case of the circular
ng choked, they had only to lift it up an inch or

two by the screw handle, and then screw it down agai the rush of water would effectually wash out any obstr

The CHAIRMAN considered that a great advantage, as it prevent any stoppage of the engine. He thought the me of the Institution were much indebted to Mr. Smith researches, but their obligations were small compared wit of the iron manufacturers of the district, with whom been more immediately brought in contact, as the proved to have been effected by the improvement of the e formed so serious a proportion to the whole expense of w them. It was important that this subject should occu attention of the iron masters, because their material mu a proportion in its price to the management bestowed manufacture. He hoped Mr. Smith would not lose s the subject, but keep it prominently before, not only iron manufacturers of South Staffordshire, but the ow steam engines throughout the country; and he thoug Institution was an excellent vehicle for the purpose, b it was only by such an Institution that information co collected in a practical form, and the results be duly i gated and considered. In conclusion, he proposed a thanks to Mr. Smith, which was passed.

The following paper by MR. ARCHIBALD SLATE, of I was then read :—

ON A BLOWING ENGINE WORKING AT HIG VELOCITIES.

In introducing to the Meeting the proposal for W Blowing Engines at High Velocities the writer of the paper wishes shortly to direct attention to the various c through which this description of engine has passed, the to elucidate the difficulties to be overcome, and the advant be derived from the further change now proposed.

st records he has been able to collect shew the blowing to be single-acting, or having the power of propelling the n the piston was moving in one direction only; three or these blowing cylinders appear to have been attached to k-shaft, worked by a water wheel, and thus a tolerably essure of air has been obtained. When the gradual ents of the steam engine and the demand for increased manufacture caused it almost entirely to supersede all er, the blowing apparatus appears to have been accom- as much as possible to the steam engine, so as to afford cter of engine for the time being, the fullest development er.

suance of this object the single-acting atmospheric Newcomen was attached to a blowing cylinder, which the air from the upper side of the piston only, and in to the water regulator, which appears to have been an earlier date, there was attached a cylinder, now the regulating tub, which was equal to or larger in than the blowing cylinder. In this was fitted a piston d moving in a guide fixed on the open top of the regu- b, the bottom of the latter being close, and having an nection to the main from the blowing cylinder. The the tub was loaded to the pressure of blast required, he intervals between the discharges of the blowing the descent of the piston in the tub kept up the of air into the water regulator, which intervened it and the furnace; thus in effect, as far as possible, he engine double-acting. To prevent the piston being t of the regulating tub, a large safety-valve was attached p of the rod by a strap, long enough to allow the desired he piston, and short enough to lift the safety-valve, or s it is usually termed, if the piston at any time exceeded ; and the number of strokes of the engine was also regu- the tub piston, as to it the cataracts were attached.

When the double-acting engines of Watt were introduc the regulating tub was still retained, though not nearly essential a part of the machine as in the former instance.

The next change that took place was the general abandonm of the water regulator (though some of these are still at wo or have been within a few years); the reason for this change the discovery that the air in summer, already surcharged w moisture, took up an additional quantity from passing over surface of the water in the regulator, and that this was pr dicial to the working of the furnaces.

When the large area of the water regulator was shut of was then found that the tub was by no means such a per regulator as it was supposed to be, as the momentum of engine passed too sudden into the heavy piston of the tub, throwing it up much beyond the height due to the pressur the air, caused an irregularity that was even more aggravated its descent; to counteract this, a spring beam was placed on top of the tub so as gradually to check the momentum of piston, and this had some effect, but not at all a satisfactory or

The next alteration which appears to have suggested it was the application of large air chambers, from twelve time thirty times the area of the blowing cylinder, in which elasticity of the compressed air acted as the regulator of discharge, the tub with its piston being in some cases retaine work the cataracts, and as a telltale against the engine m in case of their allowing the steam to slacken and the piston descend. In other cases the tub was dispensed with altogether

We now enter upon the last change which took place so fifteen years ago, namely, the coupling of two double-act engines, and double-acting blowing cylinders upon the sa crank shaft at right angles, so as to keep up a regular discha This effect was in some measure obtained, but an air cham or what is equivalent to it, very large mains, were still require obtain what was considered a satisfactory result.

At this point the realized improvements of the blowing engine stop short, leaving it still a large cumbrous and expensive machine, and not capable of moving through its valves the HIGHLY ELASTIC MEDIUM AIR, at a greater rate than the absolutely NON-ELASTIC FLUID WATER, is moved through an ordinary pump. Under these circumstances, it must be obvious that after all the engineering talent that has been spent on this description of engine, there is still (if the expression may be applied) a wide range of discovery open.

The immediate cause of the writer's attention being attracted to the improvement of the blowing engine, was the difficulty experienced in regulating one of the old construction of blowing engine in the latter part of 1848, and having at the same time occasion to employ some small 9 inch cylinders driven by the air of the large blowing engine. These small cylinders when driving the shafting only, sometimes obtained a velocity of upwards of 200 revolutions per minute, suggesting the idea of the possibility of reversing their motion and taking in the air in place of blowing it out through them; there was however a difficulty in the slide valve which did not open and shut fast enough. After some consideration it was agreed that another cylinder should be prepared, and the centre port made much larger, and the slide overtravelled nearly half its stroke in excess, which had the desired effect; a cylinder of 9 inches diameter, and 1 foot stroke, having been driven 320 revolutions or 640 feet per minute, discharging the air at a pressure of $3\frac{1}{2}$ lbs. per square inch, through a tuyere of $1\frac{1}{8}$ inch diameter, or $\frac{1}{64}$th of the area of the blowing piston. This performance, as is well known, is more than double that of any ordinary engine, the total area of the tuyeres with a 90 inch blowing cylinder, being at a pressure of $3\frac{1}{2}$ lbs., about 52 circular inches, or $\frac{1}{154}$th of the area blowing piston.

We are all acquainted with the tremour which is felt even in the best form of the large sized Engines; but in the experiments

at a high velocity with the small sized cylinders, not the slightest jar was felt or noise heard, it is therefore proposed to increase the speed of the Piston in actual practice, from 640 to 750 feet per minute, the length of stroke being 2 feet in place of 1 foot, this is somewhat under the speed of a locomitive piston at 40 miles per hour, which is about 800 feet per minute, so that it is conceived no difficulty can present itself to this. The proposed speed of 750 feet per minute, is three times the usual speed of the present blowing engines, 250 feet per minute.

The construction of the proposed engine is shewn in the accompanying Drawings; Fig. 1, Plate 11, is a plan, and Fig. 2, an elevation of the engine, shewing the pair of steam cylinders and blowing cylinders; AA are the steam cylinders, 10 inches diameter and 2 feet stroke; BB the blowing cylinders 30 inches diameter, and 2 feet stroke, with their pistons C, fixed on the same piston rods D, which are connected to two cranks E, fixed at right angles to each other on the same shaft. The slide valves F of the steam cylinders are worked by the eccentrics G on the cranked shaft, and the cranks H at the outer ends of the same shaft, work the slide valves I of the blowing cylinders. The centre port K passes downwards to an external opening for the admission of the air, and the discharge ports LL deliver into the passages M on the top of the cylinder, which communicate with the air main N by the chest O formed between the cylinders. The piston of the blowing cylinder is intended to be made without any packing, being a light hollow cast iron piston turned to an easy fit; and the slide valve of the blowing cylinder to have a packing plate at the back, working against the cover of the valve box, with a ring of india-rubber inserted between this plate and the back of the valve, to give a little elasticity.

It appears that 30 inches diameter is somewhere about the most convenient size for a stroke of 2 feet, and as it is considered an advantage to have the stroke as short as possible, to increase the regularity of the blast, the comparative cost of the different

which follows has been taken upon this basis 2-10 inch
ylinders and 2-30 inch blowing cylinders, costing together
ve of the boilers) about £400, being reckoned equal to
e of our largest furnaces, making 160 tons of iron per
nd having a surplus equal to blowing a cupola or refinery,
erally allowed, as such an engine would give at 640 feet
ute the same speed of piston as in the experiments, very
0 circular inches of tuyere, at a pressure of $3\frac{1}{2}$ lbs. to the
nch; the circular inch is used in speaking of the area of
s the blast that any furnace is taking is usually reckoned
y squaring the diameter of the tuyere, but the pressure
on the square inch.

xperiments on which these calculations were founded,
een made upwards of 12 months ago, were repeated last
d the results were found to be as nearly as they could be
l the same, the blowing cylinder had in the interval
ving the lathes in the pattern shop, and the slide was
rfect. An indicator was applied with a view to test the
of friction of the air in entering the cylinder at the high
and a simple method was adopted of ascertaining this.
e was made as large as the inlet port, and the engine was
o nearly or quite 700 feet per minute, when the guage
a pressure of $\frac{1}{4}$ of a lb. per square inch, and as the friction
e the same through the same sized openings at other
s, it follows that the loss by friction on a pressure of
$3\frac{1}{2}$ lbs. per inch, would be $\frac{1}{15}$th or $6\frac{2}{3}$ per cent. loss; as the
this case was $\frac{1}{11}$th of the area, and the port proposed is $\frac{1}{8}$th,
sumed that the loss would not exceed 5 per cent. from
se, or indeed from any other cause, as the friction from
ng the air through a given sized tuyere, at a given pressure,
the same in both cases.

wing up the comparison of first cost, we find that (exclu
Boilers, which are assumed the same in both cases, and
nto account the cost of the Engine House,) there wou...ion,

a saving by the proposed plan of between 65 and 70 per cent.; the cost of a pair of the best Engines in Staffordshire, blowing three Furnaces being £3,650, while on the proposed plan they would cost £1,100 if high pressure only, or if high pressure and condensing £1,350, including in each case the Engine House but not the Boilers.

Many will prefer high pressure only, on account of its simplicity, but as it appears evident that a given quantity of steam can be condensed in the same time, in the same condenser, whether admitted in a few large jets or in a great number of small jets, there is no reason whatever why a condensing apparatus may not be attached to the Short Stroke Engine at high velocities, the only condition being that it must be equivalent to the power of the Engine without relation to the size of the Cylinder. The Air Pump in this case must be double acting with slide valves, or it may be rotary and placed round the crank shaft, and there appears to be no advantage in a Fly Wheel for such an arrangement of Blowing Engines.

The speed of the Engine should be regulated by a Hydrostatic Governor, communicating with the Blast Main, and attached to the Throttle Valve, exactly similar to those used in Gas Works for regulating the Engine driving the Exhausters; this would regulate the Engine with greater delicacy, and maintain a more uniform Blast than can be done with the present Engines; and the rapid succession of the strokes of the two small Blowing Cylinders acting alternately, would render the present large reservoir quite unnecessary.

Supposing the advantages claimed for this description of Engine to be realized, which the writer has no reason to doubt, it may be applied to assist the present Blowing Engines where they are over-powered, which is in many instances the case, as there is no ready means of increasing their power as the works develop themselves, and greater calls are made on the Engine; but in the case of the proposed Engines, if at any time an increase were

desired another Blowing Cylinder might be added to the Shaft, at a comparatively small cost.

Referring again to what first drew the attention of the writer to this subject, the employment of small cylinders worked by the pressure of air, where it was inconvenient or impracticable to employ shafting; it has been found that a 12 inch Air Cylinder with 3lb. pressure attached to a large Foundry Crane, under which 15·30 inch pipes are cast vertically every ten hours, does the work of double the number of men that could by any possibility work at the crane.

This suggests the possibility of a very considerable advantage to Railway Companies, by the use of the proposed Engines, as the Blowing Cylinders for compressing the air might be attached to the end of the Piston Rod of any of the small sized Engines now laid up at several Stations, and the air conveyed to the various Cranes, to which Cylinders might be attached for about £25 per Crane, without disturbing the present arrangement for the use of manual power in cases of emergency. The saving of manual labour by such an arrangement will be best estimated by the Managers of Goods Departments, some of whom are amongst the Members, and with reference to the Mechanical application of the power, the writer hopes to have the pleasure of presenting the Institution with another paper at some future Meeting.

The Chairman inquired if Mr. Slate could furnish them with any comparison of the advantages of the proposed Blowing Cylinder, and the Fan-blast, which had been so well developed by Mr. Buckle at a former Meeting.

Mr. Slate said, he had used fans made according to Mr. Buckle's principle, and could speak to their excellence and superiority; they were the least expense in construction,

being made with light wood arms, and he had obtained fro
4½ to 5 oz. per square inch pressure with them. He had trie
both the cylinder-blast and the fan-blast for melting iron, an
indeed had them both now in use; but he was of opinion th
cylinder-blast was decidedly the best for the purpose, as th
fan-blast caused the lining of the cupola to burn away quicke
and also consumed a larger proportion of fuel. He had foun
they could not blow so continuously with the fan-blast, an
required to stop more frequently for repairs of the lining tha
with the cylinder-blast. The pressure of the fan-blast wa
not sufficient to carry it through the burden, so that th
passage of the air was more at the sides of the cupola, whic
caused the lining to be cut away, and hence he considered th
cylinder-blast was the best for melting iron; and though i
might not be so cheap at first cost, there was no doubt of it
ultimate economy.

Mr. Davies inquired, whether the iron manufactured wa
equally good with the cylinder-blast as with the fan-blast
and whether the hard blast did not harden the iron.

Mr. Slate had at one time entertained a similar idea, bu
he had tried both extensively, and in the thousands of ton
which he had melted, he had been unable to detect an
difference between the quality of iron made under th
influence of the fan, and that made by the cylinder-blast.

Mr. Robinson inquired, what pressure and what size
tuyeres Mr. Slate had used with each kind of blast.

Mr. Slate replied, that the pressure with the cylinder-
blast was about 3¼ lbs. per inch at the cupola, and they ha
six 1 inch or 1⅛ inch tuyeres. In the case of the fan the
had two tuyeres about 6 inches diameter. They used bes
Durham hard coke, because light coke was useless with th
cylinder-blast, which would blow it away.

Mr. Davies said, he made an exhauster that had been used extensively for blowing copper-melting furnaces, but he believed the fan was preferred, though it gave less pressure of blast.

Mr. Robinson thought the fan-blast was best for a cupola, and he could not see the reason why the cylinder-blast should not injure the sides of the cupola more than the fan-blast, because it had greater pressure, and must have more power to force its way through to the opposite side.

Mr. Slate said, the result of his observations had been that the cylinder-blast caused the least injury to the lining, and he considered that it forced its way better amongst the coke and material, on account of its pressure being so much greater than the fan-blast. He found the lining of their cupolas that had the fan-blast seldom lasted more than a few days without stopping for repairs, but those with the cylinder-blast would work for some weeks with only casual repairs.

Mr. Cowper was of a different opinion, and thought there would not be any greater destruction of the lining with the fan-blast, unless there were some other cause; the circumstance of blowing with 6 tuyeres in the one case, and only 2 in the other, might cause a difference. At the London Works the cupola was blown with a fan-blast, and had two 10 inch tuyeres at 5 oz. pressure, but they did not find the sides cut away; on the contrary, with some trifling repairs each morning before starting work, the lining of the cupola lasted for many weeks. In his opinion the fan-blast was preferable to the cylinder-blast for a cupola.

Mr. W. Smith remarked, that he did not know any instance of the fan being applied to blast furnaces in that district, and it was for those more particularly that Mr. Slate's engine was proposed; the question raised by the paper, was whether in the case of blast furnaces it was better to employ a small cylinder

at a high velocity, or a large cylinder at a slow speed. This small blowing engine was proposed to supersede the ponderous machines which were employed for the purpose at the blast furnaces; he considered it was an important suggestion, and he saw no reason why it should not accomplish the object intended.

Mr. Slate observed, that the practicability of working the blowing cylinder at the quick speed, had been proved by his trials with a cylinder driven by indirect power; and although he had not yet been able to try a complete blowing Engine driven direct by a steam piston as proposed, there was no difficulty to be overcome in driving the piston at the speed required, and the cost of the steam used would not be increased.

Mr. Cowper was of opinion that the proposed quick motion would give a more regular blast, which was a matter of great importance as effecting the make of iron; but it was a question whether the great speed at which it was proposed to be worked, would not injuriously affect the durability of the working parts of the Engine.

The Chairman did not think there was reason to fear any serious objection from that cause, when it was borne in mind that the piston of a Locomotive Engine frequently worked at the velocity of 800 feet per minute, and the proposed Engine would be stationary instead of locomotive.

A vote of thanks was passed to Mr. Slate, who promised to communicate the results of further experiments on the subject.

The following paper by Mr. Shipton, of Manchester, was then read :—

ON A NEW RECIPROCATING STEAM ENGINE.

The subject of the present paper is a Steam Engine of the reciprocating class, only differing from the ordinary Engine in the means adopted for obtaining the revolving motion direct out

of the rectilinear: the principle through which power is obtained being the same as the ordinary Reciprocating Engine, viz.—a piston acted upon by steam being propelled in a rectilinear direction in a cylinder or steam chamber, which in the present case is square or rectangular, instead of circular.

From the many often and unsuccessful attempts to obtain a continuous motion direct out of the piston, and also the variety of Rotary Engines that have hitherto appeared before the public, it is the author's wish to point out clearly the nature of this invention in the first place, so that no impression may be formed that it is of the Rotary class, but simply a Short Stroke Reciprocating Engine, the germ being "an eccentric revolving in its own diameter," which is nothing more or less than the piston and crank combined in one body, and this body containing in itself two distinct motions, viz.—rectilinear and revolving, both of which motions are common to the ordinary Engine.

Feeling convinced of the economy and good effect resulting from the ordinary Reciprocating Engine, it has been the inventor's aim to approximate as closely as possible to the principle, but they are of opinion that many important modifications and improvements may still be made; it has been their endeavour,

Firstly—That the power of the steam should be conveyed to the main shaft or axle in the most direct and simple method, (taking the oscillating engine as a fair example).

Secondly—To construct such an Engine that it may with safety be worked up to an extraordinary number of revolutions, without causing the piston to travel through an excessive amount of space.

Thirdly—To arrange such a plan that the steam may be used expansively, without inconvenience and complexity of parts.

Fourthly—To take care that no amount of the piston's surface should be in rubbing contact, except that which is the real effective portion under the action of the steam, (which the author

considers is only the case with the common cylinder and piston-engine and the one under notice, hence the excess of friction in most of the former modifications.)

Fifthly—To form certain parts of the Engine to act as fulcrums to the moving parts, so that the whole lifting power may be self-contained, and thereby secure a steady, fixed, and uniform motion.

Sixthly—To provide against any excess of wear of one part more than another, and all those parts, both internal and external, to be easily repaired, or even replaced without renewing heavy parts of machinery, such as cylinders, &c.; and also that no crooked forms and contrivances need be resorted to, to bring back the first motion into a safe and useful form, such as guides and crossheads, or parallel motions, or even the fact of a piston rod giving out its power at a considerable angle, when the crank is most effective, thus altogether depending upon the length of the connecting rod, the evil of using short rods being generally admitted.

Having thus briefly described the views of the inventors, the author will proceed to show the analogy that this Engine bears to the Piston and Crank of the ordinary Engine, and on reference to Fig. 1, Plate 12, A is the crank of an ordinary Engine, on the shaft C, in full power or the most effective position, and the whole power is conveyed through the line H, at an angle varying according to the length of the connecting rod, and the position of the crank.

It is the author's opinion, that if steam could be brought to bear upon the crank direct, it would be a more simple and ready means than at present in use, and for the sake of illustration, suppose A (Fig. 1, Plate 12) is a crank filling up completely between the sides of the Steam Chamber EF, and when steam is admitted on the top of the crank A, as indicated by the arrows, it would move into the position shewn by B; but in that position it must be observed that the same crank would be too short to

fill up the Steam Chamber, and, consequently, the steam would rush by the end D: it therefore becomes necessary to change the form of the crank, and to make it such, that at every position, the space between EF may be filled by it, which form at once resolves itself into the circle GG, with the shaft or axle C passing through it out of the centre, thus far resembling the common eccentric: and it will be seen that when steam is brought to bear upon its entire surface, as shewn by the arrows, it is thereby propelled bodily, into the dotted position II, and from the fact of being an eccentric, a revolving motion is obtained during its propulsion, and here are the piston and its appendages, and also the crank of the ordinary Engine contained in one body.

It is immaterial on what form of a piston the steam acts in case of bodily propulsion, and for the purpose of illustrating this subject further, suppose the shaft or axle, and crank to be dispensed with, and the steam to act upon the circle GG, as shewn by the arrows; this circle, or body, would be propelled in a rectilinear direction only, which would have to be converted into revolving motion in the ordinary manner, and through a number of parts. It therefore becomes a question, whether the two motions common to the ordinary Engine, viz.—rectilinear and revolving cannot be advantageously blended together in one body.

Figs. 2 and 3, Plate 12, shew Transverse and Longitudinal Sections of the Engine. A is a Steam Chamber, serving the purposes of a Steam Cylinder (therefore it will be so denominated in the following explanation), and is of cast iron; having the Plate E dovetailed in and fitted fast, and the Plate D fitted loose in the parallel recess, though sufficiently accurate to prevent any escape of steam; the Plate D is for the purpose of following up the piston as it wears, and is adjustable to its work by means of springs behind it, or by the admission of steam by a small steam-pipe, the former mode being preferable. This plate also answers

another purpose—in cases of priming the water in the Cylinde forces back the plate, and rushes from one side to the other of th piston until it escapes, and thus preventing accidents arising fron this cause.

The circular ends of the Cylinder are left black and unbored as it will be seen the periphery of the piston does not come i contact with any other part of the Cylinder but the two Plates I and E, and consequently the tedious and costly operation of borin the Cylinder is entirely dispensed with. The Plates D and E, o which the wear takes place in the Cylinder are easily replace at any period, and can be removed without taking any of the rod off by simply pushing the side Plates LL on one side. Thes Plates LL are planed surfaces, against which the Piston ends rub and the joint to the Cylinder is metallic. It will be noticed tha these Plates have holes or slots in them of a peculiar form, which are for the purpose of getting them over the cranks GG, thoug a slot of sufficient size to allow the shaft C to traverse clear woul do, if this were not the case.

The Piston B is an eccentric keyed on the shaft C, and carrie on the rods FF, vibrating from the crank-shaft pedestals; thi piston is turned true on the periphery, and in each end are turne conical seatings, into which are fitted rings of metal, KK cut ope on one side, and leaving a lap joint to prevent any escape of steam These rings are each under the control of a bolt, and can be ad justed through the slots in the side Plates LL without removing single nut, and thus are easy of access; the peculiar wear and th means adopted for obtaining a steam-tight joint are worthy o notice, and will be described hereafter.

The cranks GG are keyed on the shaft C at right angles t each other, and equidistant from a line drawn through the centr of shaft and centre of the piston, and through these cranks th power is merely conveyed through the rods or drag links HH t the lower cranks II on the main shaft, but these cranks can b keyed on at any other angle, as they only transmit the power

and consequently can be of any suitable length, independent of the stroke of the Engine.

It will be seen that the vibrating rods FF are carried on the pedestals JJ, which have a gudgeon turned in the centre on which the rod vibrates, so that all the wear that takes place on this bearing is caused by the vibration of the rod, which is very slight.

Steam is admitted by means of a valve N through the steam ports or ways MM to the top and bottom of the piston alternately, the same as in the ordinary Engine; though the construction of the valve shewn here is different, an ordinary slide valve would answer this purpose as well as in any Engine, as its office is precisely the same. This valve is on the equilibrium principle, and exhausts through the back, and works between two parallel planed surfaces, the wear that takes place being accommodated by a ring of metal O similar to that employed for packing the end of the piston; the peculiar advantages of this valve are, being light and easy, and suitable for high speeds, ready exit for the exhaust steam and extreme simplicity. This valve is worked by an eccentric Q keyed on the crank shaft P, and by levers weigh-shaft, &c.

The cylinder, &c., is bolted down to a framing or entablature, which can be altered as desired, and the entire Engine is placed on a foundation plate, and fixed in the ordinary manner.

The mechanical difficulties to be encountered in this Engine were the method of keeping the piston steam tight, and also the peculiar wear at the periphery and ends of the piston. It will be seen, that should there be an escape of steam it will readily be perceived issuing out of the slot holes in the side Plates LL. The piston ends are made tight by rings of metal KK fitted into a conical seating as before described. These rings are cast open and drawn together by a bolt after the joint is filed square; and it entirely depends upon this joint whether the ring be steam-tight, as if it be not true the ring will be drawn out of its natural

shape, and when released after it has been turned true, it will spring back to its own shape, therefore it is preferable to file the joint in such a manner that the ends of the ring may have a tendency to spring outward, and thus the difficulty is removed. It will be seen that the motion on the piston ends is an elliptical one, and from the fact of the rings being disconnected with the piston they are at liberty to move in their seating, and the peculiar motion, viz.—ellipses of all sizes, varying according to the proximity to the centre on which the piston turns, causes the rings slowly and gradually to traverse round in their seatings, thus accomplishing a most desirable object, that no two surfaces go over the same lines twice together.

The periphery of the piston has likewise a beautiful wear, as it will be seen at the same time it is revolving it is passing up and down the Plates D E the length of the stroke, and from this motion excessive wear is not anticipated.

The author will be glad to lay before a future meeting further information respecting this Engine, and its application to various purposes.

Mr. Shipton and Mr. Simpson exhibited and explained some Models illustrating the peculiar features of the invention, and shewed the front plate of the steam chamber and the conical packing of the piston, taken from an engine that had been at work for seven months, which were not perceptibly worn.

The Chairman enquired what engines of the kind were at work, and what were the results.

Mr. Simpson said they had one engine at work at Wolverhampton, driving a saw mill, which had worked well for seven months, but there was not the means of estimating its com-

parative economy. They had another at Manchester, working by the side of an ordinary high-pressure engine; these two Engines were employed alternately to drive a large Fan 7 feet diameter, with 15 arms, running about 600 revolutions per minute, and it was found by repeated trials from the quantity of coals consumed, that there was an advantage of 10½ per cent. in favour of their engine; the same work being done, and the same boilers used in both cases. The other engine was not a new one, but had been put into thoroughly good condition in every respect, for the purpose of the comparative trial.

In reply to Mr. Robinson's enquiry, Mr. Shipton said, the new engine had been patented about two years.

Mr. Robinson remembered a sketch that had been made some years before, of an engine exactly similar in principle, except that the cylinder oscillated instead of the eccentric piston; but it had not been carried out or published. He thought the engine was essentially a Rotary Engine, though termed a Reciprocating one; he considered it liable to a defect in the packing, that the steam would leak through behind the packing plate at the side of the steam chamber.

Mr. W. Smith said, he had inspected the engine at Wolverhampton; it was a very neat machine and worked well, but it was doing so little work at the time for the size of the boiler, that he could not form an opinion about its economy. He should like to see one of these engines applied to a locomotive for a month or two, which would afford the best test of its utility and economy.

Mr. Slate thought there would be a considerable wear at the lower bearings of the two vibrating rods that carried the piston, as the wear was generally found to be greater where there was a very small extent of motion, than where the motion was longer, for though the vibration was very small the friction was great.

Mr. Simpson replied, that the wear could not be more tha in the case of the centre of an engine beam, or the side ro of a marine engine.

Mr. Shipton stated in reply to an enquiry, that the engi worked 110 revolutions per minute, being a velocity of abo 200 feet per minute, but they had worked the same engi without difficulty as high as 400 feet per minute.

Mr. Robinson observed, that he had not an unfavourab opinion of the Engine, for he thought if they could by go workmanship avoid leakage, a good Engine might be made it; at the same time the difficulty experienced by others Rotary Engines would not be solved until they made a lar Condensing Engine, that would work at slow speed.

Mr. Shipton said, he did not think there was a leakage steam behind the packing plate of the cylinder as mention by Mr. Robinson, and they had tried letting in the steam the back of the plate, instead of using a spring to press against the eccentric piston; but they considered a spri was preferable.

Mr. C. Cowper observed, that though the steam leak out of the cylinder at one end of the packing plate, it mig be prevented from passing the other end of the plate, by t pressure from the friction of the eccentric piston.

Mr. W. Smith enquired what pressure of steam wou drive the Engine alone, without any load; and Mr. Shipto replied that one engine of 15 Horse-power, when quite ne was driven alone with 5 lbs. steam in the boiler, which wou probably be only 3 lbs. per inch at the engine, on account the length of the connecting pipe.

Mr. Slate remarked, that this pressure would be no criteri of the relative friction of the Engine, as different sized engin

were very different in the pressure they required to overcome the friction.

Mr. Davies observed that in many Reciprocating Engines, 3½ lbs. steam was sufficient to start them. He did not consider this engine was a rotary one, as there were two distinct motions in it.

The Chairman said the proper test of comparison would be to ascertain the relative amount of friction per horse-power in each engine, taking the new engine and an ordinary one of the same power, and measuring the actual power of each by a dynamometer.

Mr. Robinson remarked that in order to obtain accurate results they must not only try the engines by a dynamometer, but take indicator cards.

The Chairman considered that both means were requisite for a correct comparison between the engines, to ascertain their relative absorption of power, by measuring accurately the power employed by means of an indicator, and the effect produced by means of a dynamometer. He observed that they would be glad to receive the results of such a trial of the Engine described in the paper, and proposed a vote of thanks to the author, which was passed.

The following paper, by Mr. Thomas Thorneycroft, of Wolverhampton, was then read,

ON THE FORM OF SHAFTS AND AXLES.

In order to arrive at proper proportions for any of those principle media of power, which are so fully employed in almost every branch of manufacturing science peculiar to this kingdom, two or three leading points obtain, as axioms on which to reason, in order to arrive at satisfactory results.

Taking, for instance, Iron as the material in question, it required to apply it in an entire new sphere of mechanic movement; the first leading point for examination is the la which limits the Tensile and Compressive powers of th material, and should the various forces which are about to b put into operation, be by any means calculable quantities, th Tensile and Compressive powers of the material being dete mined, there is before us an easy mode of arriving at satisfactor results.

It has, however, been found of equal importance thoroughl to investigate the cause of every failure in this material, an mark those parts where the greatest amount of weakne appeared, so that in re-construction, the simple laws of strengt as determined by experiments, are applied in connexion wit the results of practice, in producing principles of form, an mechanical arrangement, better and safer than either of the alone would have done: yet, notwithstanding that by thes means safer results have been obtained and brought into us from the rapid advance of mechanical contrivance, the movin parts of machinery are being daily subjected to untried an incalculable forces; hence the necessity of uniting to forme experiments and practice, experiments and contrivances, closely analagous to the peculiar circumstances which are foun to operate so powerfully in deteriorating and destroying th most valuable material now under consideration.

It would be deeply interesting to trace the many chang which have taken place in the formation of the various stru tures, both of Cast and Wrought Iron, which have been brough into use during the last fifty years; some of these remain to th present monuments of the skill of their projectors, and at th same time proofs of the soundness of the principles on whic they have been constructed: on others, causes have been i constant operation, gradually reducing the strength of th

ıass until they have become unfitted for the purposes ection.

a few instances these causes of weakness have been ınd proper remedies applied, by better arrangement of and, in some instances, by the adoption of entire new of construction.

ttention is directed to the Bridge class of structures, e that, previous to the introduction of Railways, the ral form was the simple Arch, which, whether con- Cast or Wrought Iron, there is left indisputable proof rch as a principle cannot be excelled, either for sta- lurability, and that, simply because there are in it ıents of self-destruction than in any other form or vhich has been applied for the like purpose. Hence o much to presume, that just in proportion as we leave ɔle of the Arch, and approach that form which neces- ıany cases, has rendered imperative we introduce which, if not carefully watched, must sooner or later l to the stability of the mass.

mine what these elements of self-destruction are, and xtent they are in operation, has lately occupied the thematical and practical talent of this kingdom; and recorded as the result of their experiments and investi- t to resist the effects of reiterated flexure, iron should allowed to suffer a deflection equal to one-third of its eflection, for should the deflection reach one half of its flection, fracture will sooner or later take place. It is, reasonable to conclude, that the greater the amount of is practicable to introduce into structures of this nature, will be the self-destroying elements in operation, and ly, the greater their durability.

ductions will receive very considerable support from of the various descriptions of Shafting employed in ent manufactories of this country; previous to the

introduction of the Slide Lathe, the Shafting employed in th spinning manufactories was a constant source of vexation an expense, the want of that perfect parallelism which is no obtained, exposed the Shaft to vibration or bending at every rev lution, the consequence was, constant fractures. The same result have been observed and recorded in reference to the shafting i use in the iron works of this district; and if we pass to the Mai Shafts of Water Wheels, or the Intermediate Shafts of Marin Engines, we see that what at one period of their history wa considered good in principle, (viz.—Paralled Shafts,) have had t give place to others, more generally of increased diameter at th centre, or if parallel greatly in excess of former practice. Perhap no better case could be selected than that of the Intermediat Shaft of a Marine Engine to illustrate the subject now befo the Institution, for there might be traced an almost perfe agreement in all the forces which act upon that Shaft, and on th Axles of either Engines or carriages on a Railway.

The author of this paper being a manufacturer of Railwa Axles, has had his attention drawn to the subject of the form Axles for some considerable time; and from his knowledge the properties of iron, and his observations of the fractures Shafts and Axles, has concluded, that various forms of Shaf and Axles possess elements of self-destruction—that the fractur which take place are generally confined to given parts, and tha those parts where fractures take place, exhibit errors of mechan cal construction, or errors of mechanical arrangement, when i motion.

A very extensive course of experiments has been gone throug by the author, approximating as closely as possible to the forc on Axles when in use; and these have satisfied his mind, tha just in proportion as there are departures from certain fixed pri ciples of construction in either Shafts or Axles, in the same pr portion will be their liability to fracture.

Before passing to an examination of the experiments, it ma

more correct elucidation of the subject if the Railway iewed as having certain relations to a Girder in prinrders generally have their two ends resting on two upport, and the load is either located at fixed distances Props, or dispersed over the whole surface; just so Axle; it has its points of support and its loaded parts; ot clearly evident which are the loaded parts and which It has been stated that the Wheels may be con- Props, and the Journals the loaded parts; but it is at with equal property the Journals may be considered and the Wheels the loaded parts: if this latter opinion missable, we then have the load brought much nearer of the Axle than in the case where the Journals are the loaded parts; and, besides, it brings more im- before us the influence which the inclined bearing the Wheels will necessarily have in increasing the any Lateral, or Vertical Blow, which the Axle will rough the Wheels. It is found that the inclined sur- Wheel Tire ranges from 1 in 12 to 1 in 20, and, as a ourse, the direct tendency of the Wheels under a load nd that incline, so that every Vertical Blow which the ay receive is compounded of two forces, viz.—the one e Wheels in the direction of their Vertical Plane, and to move the lower parts of the Wheels together; it n that these two forces have a direct tendency to bend somewhere between the Wheels; should that yielding, , extend no farther than one-half the elastic limit, tinued, fracture will ultimately take place; but should limit be exceeded, the Axle takes a permanent bend, ls are then diverted from their Vertical Plane, and r of course, leave the Rails. To demonstrate this is the the first experiment. An Axle reduced in the middle diameter was placed upon two Props 4 feet 9 inches loaded in the middle, the utmost of its deflection with-

out a permanent set, was ·232 inches, the load carried 7 tons. An Axle reduced to 4 inches in the middle, and then placed upon the Props 4 feet 9 inches apart, its utmost deflection without a permanent set was ·281 inches, the load carried 9 tons. Another Axle, but parallel, $4\frac{5}{16}$ inches diameter, was placed upon the Props 4 feet 9 inches apart, its utmost deflection, without a permanent set, was ·343 inches, the load carried 14 tons. Hence, by reducing an Axle of $4\frac{5}{16}$ inches diameter in the middle to $3\frac{3}{4}$ inches, its limit of elasticity is reduced from ·343 inches to ·232 inches, and the load to produce that elasticity from 14 to 7 tons. Fig. 1, Plate 13, shews the position of the Wheels to the Rails when the bending of the Axle has exceeded its elastic limit.

The object of the second experiment was to ascertain what influence the reduction of an Axle in the middle would have on its strength to resist sudden impact, compared to an unreduced one; this Axle was made as represented by Fig. 3, which shews the end A parallel to the centre $4\frac{1}{2}$ inches diameter, and the end B is drawn down from the back of the Wheel towards the centre, where it is 4 inches diameter. The end A was then subjected to impact—the relative position of Prop and Ram was the back of the Wheel and the neck of the Journal, this End received 46 blows of the Ram, and bent to an angle of 18°. The end B was then subjected to impact—the Prop and Ram in the same relative position, when it bent back to an angle of 22° with only 16 blows of the Ram, (as shewn by the dotted lines in Fig. 2.) The object of the third experiment was to ascertain what influence a Shoulder behind the Wheel would have on the strength of the Axle at that part compared to one without a Shoulder. Fig. 3 and 4 were one Axle cut in two, the end E was turned from the neck of the Journal, leaving a Shoulder $\frac{1}{8}$th inch deep as a stop to the wheel; the end F was turned from the neck of the Journal to the same diameter, but no Shoulder left. The end E was subjected to Hydraulic pressure, the load being in a direct line with the

Shoulder, when it broke in two with a load of 60 tons. The end F was subjected in the same way to Hydraulic pressure, when it bent into the form shewn by the dotted lines, with 84 tons. The object of the fourth experiment was to ascertain what influence the position of the Wheel in relation to the neck of the journal would have on the strength of the Journal under impact. Fig 5 was a piece of an Axle, with a Journal taken down at each end; the end G was keyed into a cast iron frame, the face of the frame in a line with the neck of the Journal, the Journal was then subjected to the impact of a Ram falling 10 feet, when it broke off at the 7th blow. The end H was keyed into the cast iron frame in the same way, but with the neck of the Journal projecting 1½ inches from the face of the frame, the Journal was then subjected to the impact of the same Ram falling 10 feet, when it broke at the 24th blow.

From these experiments, and from the acknowledged deteriorating influence of vibration or bending on iron, especially when continued any great length of time, it is the author's opinion that neither Shafts nor Railway Axles ought to reduced in the middle, but rather, if there is to be a departure from the parallel form, they should be made thickest in the middle, and thus effectually prevent any vibration or bending whatever; for it is the introduction of this principle into almost every description of Beam and Girder, also into the Connecting Rods of every description of Steam Engine, and into a large quantity of the Shafting now in use, that has rendered the whole of these articles so superior in point of durability, to what they were when other principles of form were in use.

Mr. Thorneycroft gave a further illustration of the paper by reference to several specimens of axles which were exhibited to the meeting. Having obtained an axle which had a shoulder

F

at both ends, he turned the shoulder off one end but left it
the other, and he found that in the instance where the shoul
was turned off, it required a pressure of 120 tons to break
and 1½ inch deflection; while the other end, where the shoul
was not turned off, broke with a pressure of 105 tons and ¾
an inch deflection.

The CHAIRMAN observed that, as there was not time for
discussion of the paper at that meeting, it had better
adjourned to the next meeting, more especially in the abse
of their President, who took so great an interest in
subject.

MR. THORNEYCROFT said, that between that time and
next meeting, he should be happy if any members of
Institution would visit his works, and test the truth of
positions advanced in his paper, and suggest any ot
experiments to investigate the subject.

A vote of thanks having been passed to MR. THORNEYCRO
for his communication—

The CHAIRMAN announced, that the Committee appoin
to consider the best means of perpetuating the memory
their late President, MR. GEORGE STEPHENSON, were not as
prepared to submit a definite proposition as regarded
form in which the memorial should be carried out; but t
would soon be in a position to do so, and he was happy
state that the movement which originated with this Institu
would be carried into effect as a general one, as a numbe
the personal friends of MR. STEPHENSON, who by their na
and position would carry great influence, had joined
Committee appointed by the Institution and determine
unite in their exertions, and he had no doubt that the re
would be the erection of a suitable testimonial to the mem
of so great a man.

The CHAIRMAN then announced that the ballot lists had been opened by the committee appointed for the purpose, and the following new members, &c., were duly elected:—

MEMBERS.

JOHN BROWN, Sheffield.
JOHN HARTLEY, Wolverhampton.

GRADUATES.

GEORGE GLYDON, Birmingham.
WALTER WILLIAMS, JUN., West Bromwich.

The meeting then terminated.

PROCEEDINGS.

OCTOBER 23, 1850.

...RAL MEETING of the members was held at the
the Institution, 54, Newhall Street, Birmingham, on
...y, the 23rd October, 1850; J. E. M'CONNELL, Esq.,
...sident, in the Chair.

...inutes of the last General Meeting were read by the
..., and confirmed.

...hairman announced that, according to the Rules of
...itution, the President, Vice-Presidents, and the follow-
... of the Council in rotation, would go out of office at
... of the present year; and that at the present meeting
...ncil and Officers for the succeeding year were to be
...ted for the election of the next Annual Meeting.

...SIDENT	Robert Stephenson, Esq., M.P.
...E-PRESIDENTS	Charles Beyer, Esq., Manchester. J. E. M'Connell, Esq., Wolverton. John Penn, Esq., London.
...OUNCIL	E. A. Cowper, Esq., Birmingham. Edward Humphrys, Esq., Woolwich. Edward Jones, Esq., Bridgewater. W. A. Matthews, Esq., Sheffield. Archibald Slate, Esq., Dudley.
...REASURER.........	Charles Geach, Esq., Birmingham.
SECRETARY.........	Wm. P. Marshall, Birmingham.

...ese were proposed for re-election, with the addition of any
...her members who might be proposed by the Meeting.

Mr. James A. Shipton, of Manchester, was proposed by M Bowman for one of the Council, and no other names havi been added by the Meeting, the list was adopted.

The Secretary then read the following supplementa paper, by Mr. Thomas Thorneycroft, of Wolverhampton:–

ON THE FORM OF RAILWAY AXLES.

Since the reading of the paper on the form of Railway Axles, t author has had his attention specially directed to some of th points which it was the object of the paper to introduce a support.

In that paper, as well as others on the same subject, parallel had been drawn between the Railway Axle, and the Gir as being somewhat alike in principle; admitting the correctn of this opinion, the question would arise, why is the princi upon which every girder is made departed from in the case of Axle? If it is pleaded that the close proximity of the p and load, and these acting at the extreme ends of the Axle, justified this departure from the Girder principle; then it mi be expected that girders loaded under very similar circumstan would in like manner be reduced in the middle; but not so; a case in point, reference might be made to the girders wh suspended those parts of the Britannia Tubes which pass thro the towers, where the prop and load are at the extreme end the girder, and within a few inches of each other; yet th girders are parallel, although for a distance equal to the wi of the tube there is no load whatever.

The principal reason which has been assigned for reduc axles in the middle, is the supposition that when parallel, effect of the forces from lateral and vertical percussion tends break the Axle behind the Wheel; that being the point wh the greatest amount of fractures have taken place: the autho however of opinion, that the simple and only cause of the fractur axles at that particular point is the shoulder, which it has b the practice to leave on the axle as a stop to the wheel; some of

experiments now before the Institution prove at least, that where a shoulder exists the strength of the axle is reduced more than one-half, which affords presumptive proof that there are other causes in constant operation (beside the arrestment of the wave of vibration), inducing fracture at that particular point.

It has now become the opinion of some Engineers that in every case of collision or other derangements of a Train when in motion, that axles reduced smaller in the middle are unable to keep their form, and that such axles exposed to violent lateral blows are easily sent beyond the limit of their elasticity, the consequence is the wheels leave the rails and contribute directly to greater damage than would ensue were the train to keep the line.

A short time ago some disarrangement of a Train took place on the Shrewsbury and Birmingham Railway, in which case three or four carriages were nearly broken to pieces; the axles of these carriages were all reduced in the middle, and nearly all of them were more or less bent, while some of the carriages in the same train with parallel axles suffered little or no damage, and there was not one parallel axle bent in the slightest degree. Such a result might have been anticipated when it is remembered, that the resistance which the middle of an Axle offers to a bending force is as the cube of its diameter. Hence, if we take the diameter of the centre of a reduced Axle at $2\frac{5}{8}$ inches, the cube of which is 18·08, and then take the diameter of a parallel Axle of the same weight, which would be $3\frac{1}{4}$ inches, the cube of which is 34·32, we find that with the same quantity of material the parallel axle has the advantage of the reduced one, to resist all the forces to which axles are subject by 90 per cent. So early as 1842 the Mechanical Section of the British Association had the subject of the fracture of Railway Axles fully discussed, after a number of excellent remarks by Mr. Nasmyth on the different causes which tended to destroy the fibre of iron, and render it brittle; he observed, that simply nicking iron to the extent of only $\frac{1}{100}$th of the area took away $\frac{1}{10}$th of its strength:

Mr. Fairbairn at the same time expressed his opinion that the tw chief causes of the breakage of Railway Axles were bending an percussion, these changed the fibreus to the crystalline structur In a paper read by Mr. J. O. York before the Institution of Civ Engineers in 1843, reference was made to the fleeting bars used a levers for turning the large screws for forcing forward the shiel in the Thames Tunnel, that they never lasted longer than three o four weeks, although very strong and made from the best material and that when fracture took place they exhibited a bright crysta lized appearance, clearly shewing that oft repeated bendin without any concussion had destroyed the fibre of the iron, an rendered it quite brittle.

A mass of evidence might be adduced to prove that the intern structure of iron undergoes no change, unless there be a change form; and that simple jarring or vibration will not destroy t fibre of iron, whereas bending, if long continued, will chan the most fibrous iron into crystalline, therefore the author wou fully subscribe to the opinion of one of the Railway Commissione who has stated, "that it was of importance to avoid deflection Railway Axles, as deflection was almost as fatal as fracture causing accidents."

Mr. Thorneycroft gave an explanation of the experimen which he had laid before the preceding meeting, and the spe men axles exhibited on the table. Supposing that an ax bent in the centre, it must have a tendency to throw t wheels off the line; and as every time it turned round it wou bend backwards and forwards, if it were bent more than t point of elasticity, it would have a tendency to snap off at t point where it was firmly fixed. If the axle were bent beyo its elastic limit, it would take a set and would not co

pletely go back again; and, consequently, as the bending would alter the shape, as there was a constant action going on it would have a tendency to produce permanent injury of the iron, and in time it would break off short, because whenever there was an alteration from the fibrous into the crystalline state, it would snap off at the point where it was rigidly fixed, namely—at the inside part of the wheels. The object was to get at the best form of axle possible, and to shew that there might be improvements in the generality of axles at present used. Axles had generally been reduced in the middle, but the experiments appeared to shew that in point of security great advantages would be gained by making the axle parallel all the way along instead of reduced in the middle, since the latter were found very frequently to snap close to the wheels.

Mr. Bowman expressed his opinion, that it was unphilosophical and unmechanical either to reduce axles in the middle, or to make a shoulder behind the wheel. He considered the reduction of an axle in the middle must have a tendency to reduce its strength; and that by taking away the shoulder from behind the wheel, the principle cause of fracture at that point would be removed.

Mr. Slate fully agreed with the view expressed as to the removal of the shoulder behind the wheel, but if the illustration given in the paper derived from the girder suggested anything, he thought it was like strengthening a girder in the middle when it proved weak at the ends. When a strain was put on the flange of the wheel, the point of fracture would be behind the wheel; but if there were any analogy between the cases of the axle and the girder, it would tend to shew that the axle would break in the middle. The proposition brought forward was, that if the axle were made so stiff that there was no vibration, it would not be so liable to break behind the wheel; but he did not conceive that any addition

of strength in the centre would produce strength behind t
wheel. Indeed, where the elastic action was the greatest t
fracture would take place, and by making the axle stronger
the middle the elastic action would be greatest at the whe
and the liability to fracture at that point would be increase
because the flexibility would be confined to the part at t
wheel instead of being diffused over the whole axle.

MR. T. THORNEYCROFT remarked, that the girders allud
to were parallel all the way along, and they supported t
whole weight of the tube from the two extreme ends. Suc
also, was the case with the axle which supported the weig
not in the middle, but at both ends.

MR. PEACOCK remarked, that the material must be tak
into account, because the girder alluded to was of cast-ir
and if it had been reduced in the centre the strength mig
have been injured before it left the foundry by unequal co
traction; but in the case of the axles, being of wrought-ir
there was a great difference.

MR. T. THORNEYCROFT said, the girder had to sustain a gr
weight, and so had a railway axle; and in process of time t
structure of the iron would be injured by bending backwa
and forwards. He fancied that the object in view was t
same which he entertained in giving the railway axle streng
in the centre because by bending they destroyed the origi
form of the iron, and thereby changed its structure, and th
the object was to prevent the girder bending in the centre.

MR. SLATE remarked, that if the girder were reduced in t
centre it would be liable to be broken there by vibration.
there was any analogy the axle also would break in t
centre; but that was not the fact.

MR. BOWMAN said, that axles broke in the centre; two
three cases had come to his knowledge, though he had n
much experience on railways.

The Chairman observed, that as it was an important point, he should like to elicit from such members as had experience, what number of axles they had seen broken in the centre.

Mr. H. Wright said, he had never seen one, that he was aware of.

Mr. Ramsbottom had frequently seen axles broken near the end, but had not met with a single case of an axle breaking in the centre.

Mr. Peacock concurred with the preceding speaker.

Mr. Allan said, he had seen a leading engine axle broken within a few inches of the centre, but for that one he had seen probably 500 axles broken at the wheel.

Mr. Owen had seen some thousands of broken axles, but he was not aware, through many years experience, of one axle breaking directly in the middle.

Mr. Henson had never seen one break in the middle, and thought that many thousands broke at the wheel compared to one at the middle.

The Chairman said, the result of his experience fully agreed with the preceding observations, that it was very rare for axles to break in the centre.

Mr. T. Thorneycroft inquired whether any member had seen any of the parallel axles broken close by the nave of the wheel.

Mr. Henson said, he had seen a large proportion of them so broken; some of these had very slight shoulders, the others larger ones.

Mr. Cowper said, it seemed to him that Mr. Thorneycroft's conclusions were arrived at by experiment, unaided by theory. In the accompanying sketch, Fig. 1, Plate 14, if they took A B as the axis of a railway axle, A and B as the centres of the journals, and C as the centre of one wheel, they would

have the case of a girder weighted at A and B, and support at C; the proportionate *strength* ought, therefore, to be as a t angle ACD, and a triangle BCD. Now if they put two of the triangles together, as at E E, they would at once arrive at t result that the strength of the axle should be uniform betwe the wheels, and consequently parallel, and from the wheels the journals, the strength should be as a triangle; and if th had merely to do with a strain due to the weight on t journals of the axle, these proportionate strengths would strictly correct. *But* they had another enemy to deal with they had to provide against the lateral strains from t flanges of the wheels suddenly striking the switches a crossings in passing through them; and this was so mu greater than the mere weight on the axle, that it must considered chiefly in determining the form of an axle; therefore, the Figure A C B D were reserved on itself, outline thus given would represent the proportionate *strengt* an axle, as at F F, which was fully in accordance with usual tapered form of axles. *The actual diameters* could, course, be easily arrived at, by taking the cube root of width; as it was well known the *strength* of solid cylind are as the cubes of their diameters.

Mr. Shipton observed, that experience shewed that an a should be a rigid body; hence he understood the idea of writer of the paper to be—that elasticity in the centre tend to ultimate fracture.

Mr. Bowman said, the parallel axle was adopted to do aw with the deflection. In the cases of parallel axles referred as being broken, there were shoulders behind the wheel, what they wanted to find was an instance of a parallel a without a shoulder being broken.

Mr. Slate observed, that he had suggested the introduct of a small shoulder inside the boss of the wheel, near the ou

side, (see A, Fig. 2, Plate 14,) which he thought would have all the advantage of the shoulder at the inner side of the boss, without weakening the axle at all. The wheel was to be bored out a tight fit, and forced on to the axle by a press, but the first 1½ inch from the inner side was to be slightly coned as shewn at B, so as to remove the grip on the axle from the extreme edge of the boss, and prevent the tendency for the axle to break at that point.

The CHAIRMAN said, they had found, a considerable time ago, that in the use of the square shoulder there was a great liability to cause fracture; hence they adopted the present form, which is countersunk into the wheel, from the inner edge of the boss, with as small a taper as possible : the difference of the axle in its rough state and when turned true, being sufficient for the purpose, bevilled off into the wheel, as the wheel boss was bored accurately, and forced on tight by a hydraulic press. The shoulder was thus entirely avoided.

MR. MIDDLETON observed, that he had proposed some time ago that a cone of about one third the length should be carried into the boss of the wheel, or rather a large hollow; and in turning up the axle he would leave no shoulder at all.

MR. WILLIAMS said, there was no doubt a parallel axle would be the stiffest, but the question was, whether it was the most efficient. If a bar of iron was repeatedly bent backwards and forwards in the middle, it would certainly become crystalline and would break in the centre; but axles did not break in the centre, hence the illustration did not hold good.

MR. COWPER remarked, that a parallel axle or bar of iron, fixed near one end in a vice, and worked about at the other end, would break at the vice, no doubt, like the axles breaking at the point where they are fixed in the boss of the wheel; but he could conceive the possibility of it being reduced from that point to the other end in such a taper that they could

not tell where it would break, and it would be equally strong throughout.

Mr. H. Smith said, whether the shoulder were square or not, he was of opinion that axles were more liable to break at that part than any other. He might observe that the axletrees of gentlemen's carriages were made parallel, and he had known many of them broken in the centre as weli as at the shoulder.

Mr. Peacock observed, there was no doubt a collar behind the wheel was bad. The question was only, whether the parallel axle or the taper axle was best. He considered that if Mr. Thorneycroft's experiments had been tried, by giving the blow on the wheel instead of the journal, he would have arrived at very different results, and at results also which bore much more upon the practical determination of the question. In the experiment mentioned, where the short end of an axle broke off with seven blows, as contrasted with the other end which took twenty-four blows to break it, he thought that the fracture was not caused by weight alone, but by vibration, otherwise the short end must have borne a greater weight than the long projection. As the results of the experiments did not coincide with his own experience, he would suggest to Mr. Thorneycroft that he should try other experiments, by applying the blows to the flange of the wheel instead of the journal; and that he should apply this test both to the parallel and taper axles, dispensing with the collar in both cases.

The Chairman referred to the experiments on the form of axles that he had laid before the Institution on a previous occasion, in which he had applied the force to the edge of the wheel, and the results confirmed the taper form of axle. (See paper by Mr. M'Connell in Proceedings, October 1849, and January 1850).

Mr. G. B. Thorneycroft remarked, that it was simply with

the view of determining the most philosophical and mechanical form of axle that he had paid attention to this subject. He considered that a shoulder, whether inside the wheel or outside, was decidedly objectionable. When force was applied, either by pressure or by a blow to a parallel bar of iron, it bent and the fibres drew out; but the moment they turned a shoulder in any part of the bar, they cut through the outer fibres of the iron, and they could not draw out the inner from under the outer fibres, and the bar snapped short like a stick. He did not maintain that the parallel axle never broke, but he considered that it would take half as much more force to bend a parallel axle as would be sufficient to bend a tapered one. Neither did he say that axles, parallel or taper, broke in the centre; he did not think they did, but that if an axle was prevented bending in the centre, strength and security were thereby gained.

The Chairman observed, that in order to institute a fair comparison of the relative strength of the taper and the parallel axle, it was necessary to take care that the same weight of iron was employed between the wheels in both cases; if the parallel axle weighed more than the taper axle, it was not a fair comparison of strength. The diagrams exhibited did not shew as much strength of metal in the taper as in the parallel forms.

Mr. G. Thorneycroft replied, that he considered a parallel axle of the same weight with a taper axle would be much the stronger.

Mr. Ramsbottom remarked, that the conclusions as to the correct form of axles arrived at by the writer of the paper were entirely different to his own conclusions and experience. He always considered that, whether in the case of axles or machinery of any kind, there must be an error in the proportions, if any one could say beforehand at what point a fracture was likely to occur. There could not be any question that a

shoulder behind the wheel was objectionable, since any sudden variation in the strength must lead to a disturbance of the forces, and eventually to fracture. He could only conceive one instance in railway practice where axles should be parallel, and that was in the case where the forces were applied in a line directly parallel to the axle; as at AA, Fig. 3, Plate 14. If a pair of wheels were running, for instance, between rails converging to a point, the axle should be parallel, since the effect of the leverage was the same at all points BB between the wheels. But there was another and more important force resulting from a lateral blow upon one wheel only, coupled with the load of the vehicle on the axle, the direction of which would be tolerably well indicated by a line C D Fig. 4, drawn from the circumference of the wheel on one side to the centre of the journal on the other side; and if the line FF was drawn perpendicular to this, from the axle close to the wheel, it would represent the greatest effective leverage, tending to break or strain the axle at that point; and the strain upon any other point of the axle might be found by drawing lines GG parallel to this, in fact the cube roots of these lines would give the diameter of the axle at the points where they fall.

He had remarked that some of the early axles were parallel throughout, but an alteration had been introduced, and they now found the least weight of metal in the centre. Notwithstanding this he believed the principle was not carried out sufficiently far, since he had never seen a single case of a fracture in the centre of an axle, whilst he had seen a great many broken close to the wheel or near it. This, in his opinion, was sufficient proof that they were not carrying out the principle of taper axles so far as mechanical science and experience suggested.

Mr. T. Thorneycroft suggested, that the further consideration of the question should be adjourned, and offered before

the next meeting, to try further experiments and lay the results before the members. He would take a long axle, cut it into two parts, each the same weight, and reduce one in the middle, and keep the other parallel all the way along, taking care that the same weight or metal should exist between the props in each case. He invited members to attend and inspect the experiments whilst they were going forward.

Mr. G. B. Thorneycroft remarked, it was at the point where the strain took place that the axle broke, and experience shewed that by bending iron frequently backwards and forwards it may be rendered crystalline.

The Chairman observed, that a considerable degree of light had been thrown upon the subject by the discussion. In the conducting of any experiments on axles, it was necessary that they should be subjected to natural blows or forces, as similar as possible to those that they are subjected to in practice, because the point which they wanted to ascertain was the positive result in actual working. It had been well observed that the wheel was the anvil or hammer from which the axle received its blow; but, in addition to this, there was a jarring force as well as a bending force, all tending to break it. The experiments that he had previously made had been conducted on that principle, and the force had been applied to the wheels, which was requisite in order to obtain true results. As the subject was one of vital importance to railway interests, and materially affected the question of safety in travelling, he thought too much attention could not be bestowed upon it; and the discussion had better be adjourned to a future meeting.

The Chairman, in reference to the succeeding paper, observed, that he had the pleasure of exhibiting to the meeting for the first time, the first Locomotive Engine that was ever made; to William Murdock was the credit of it due, and the engine before the meeting was invented and constructed by that ingenious man, at the early period of 1784.

The following paper, by Mr. William Buckle, of Soho, Birmingham, was then read:—

ON THE INVENTIONS AND THE LIFE OF WILLIAM MURDOCK.

The late William Murdock was born at Bellow Mill, near Old Cumnock, Ayrshire, in 1754, where his father, an ingenious man, carried on the business of millwright and miller, and also occupied a farm on the estate of the Boswell family of Auchinleck, by whom he was much esteemed for his integrity and ingenuity. His mother's maiden name was Bruce, and she used to boast of being lineally descended from Robert Bruce of Scottish History. They had several children who died before William Murdock, without shewing those talents that enabled him by his inventions, in so great a degree, to benefit mankind.

So remarkable a man, whose talents and inventions have contributed to the advantage of society, and whose ingenuity was so well known, should not be allowed to go out of the world without some special notice.—Little is known of his habits and pursuits prior to his joining the establishment of Messrs. Boulton and Watt, at Soho, in the year 1777, then in its infancy; but he must before he left his native country have had celebrity, as he was employed to build a bridge over the River Nith, in Dumfriesshire, a very handsome structure, which still exists.

His talents were soon justly appreciated at Soho, particularly by the celebrated James Watt, with whom he continued on terms of the warmest friendship to the time of Mr. Watt's death in 1819.

After a short residence of about two years at Soho, Messrs. Boulton and Watt appointed him to superintend the erection and undertake the general charge of their Engines in Cornwall, where he erected the first engine with the separate condenser in that district, and he remained there giving great satisfaction to the mining interest until the year 1798. As a proof of his use-

fulness, when the adventurers in the mines heard of his intention to leave Cornwall and return to Soho, they used all their endeavours to retain his services, and offered him £1000 a year to remain in the County, but his attachment to Soho and his Soho friends, could not allow him to comply with their urgent request.

In the year 1785 he married the daughter of Captain Paynter, of Redruth, Cornwall, and he had four children, of whom only one son survives. His wife died in 1790, at the early age of 24 years.

In the year 1798 Mr. Murdock returned to take up his permanent residence at Soho Foundry, and superintended the erection of the machinery there, and occasionally the erection of engines at a distance, amongst which may be mentioned the Engines of the New River Head, Lambeth, Chelsea, Southwark, East London, West Middlesex, and several other Water Works. His energies to further the interests and celebrity of the Soho establishment were not used in vain, for they assisted, in no slight degree, in procuring for it a name celebrated throughout the civilized world.—His time there, and for years after, was so completely occupied by his mechanical pursuits, that he had no leisure to devote to any sort of recreation. The rising sun often found him after a night passed in incessant labour still at the anvil, or turning-lathe, for with his own hands he would make those articles he would not trust to unskilful ones.

Mr. Watt, in his Notes on Dr. Robinson's Treatise on the Steam Engine, bears testimony to some valuable improvements by Mr. Murdock; and others are recorded in a Patent he took out in 1799, which included—

1st.—Boring Cylinders by means of an endless screw working into a toothed wheel, instead of spur gear, for the purpose of producing a more smooth and steady motion.

2nd.—Steam Cases for Cylinders cast in one piece fitted to the Cylinder with a conical joint at the top and bottom, instead of being made in separate segments bolted together with caulked joints, according to the previous practice.

3rd.—The Double D Slide Valve in place of the four poppet valves, in Mr. Watt's Double Engine for the purpose of simplifying the construction and working, and saving the loss of steam in the two steam chests at each stroke; also the Cylindrical Valve for the same purpose, with a revolving motion either continuous, or reciprocating through part of a circle.

4th.—A Rotary Engine was also included in this Patent, which is shewn in Figs. 1 and 2, Plate 15, consisting of two wheels AA, with teeth BB working into each other, and fixed in a case C, which fits close to the sides of the two wheels and the ends of the teeth, these parts being made steam-tight by packing D. The steam is admitted on the upper side at E, and presses on the teeth of the two wheels, driving them round in the direction of the arrows, and passing out to the condenser on the lower side at F. Mr. Murdock had one of these Engines of about a half-horse-power set to work about 1802, at the Soho Foundry, to drive the machines in his private workshop; it continued there for about 30 years, and often in nearly constant work, and it was found to work well. This Engine is exhibited to the present meeting.

Now that Locomotive Steam Engines have become so extensively used, it is proper to record that the first was made by Mr. Murdock, upon the principle of the non-condensing engine, described in the 4th Article of Mr. Watt's Specification of 1769, (since adopted in all engines for that purpose), and this engine was seen in 1784 by persons still living, drawing a small model waggon round a room in his house at Redruth, where he then resided.

This original Locomotive Engine was frequently exhibited by him to friends, at his house, at Handsworth, up to the time of his death; it is still in working order, and is exhibited to the present meeting, being now 66 years old. It was constructed entirely by his own hands. The Engine is shewn in Figs. 1 and 2, Plate 16. The Boiler A is made of copper, with the flue B passing obliquely through it, and is heated by the spirit lamp

inder D $\frac{3}{4}$ inch diameter and 2 inches stroke, is fixed of the boiler, and the piston rod is connected to the Vibrating Beam E, to which is attached the connecting working the crank of the driving wheels G, H is a ndrical Slide-valve worked by the beam E, which strikes rs II on the valve spindle, and the steam is exhausted hollow spindle of the valve passing out near the of the wheels only is fixed upon the crank axle, and a l is placed in front working in a swivel frame to allow o run in a small circle.

me that Mr. Murdock was making his experiments ocomotive Engine, he greatly alarmed the clergyman ish of Redruth. One night, after returning from his e mine, he wished to put to the test the power of his as railroads were then unknown, he had recourse to eading to the church situate about a mile from the s was rather narrow, but kept rolled like a garden bounded on each side by high hedges. The night was e alone sallied out with his engine, lighted the fire or the boiler, and off started the Locomotive with the full chase after it. Shortly after he heard distant ce shouting; it was too dark to perceive objects, but und that the cries for assistance proceeded from the tor, who, going into the town on business, was met in road by the fiery monster, whom he subsequently took to be the Evil One in *propria persona.* Whoen on one of our modern railroads on a dark night, n approaching train—now no novelty—may easily at effect the awful sight would have on the nerves of gentleman of the last century; and although the s of small dimensions, yet it was a total stranger, and ked for, in such a locality.

rdock is still better known to the public, and most so, by his invention of applying the light of Gas from nomical purposes.

In the year 1792 he employed Coal Gas for the purpose of lighting his house and offices at Redruth, in Cornwall; and this appears to have been the first idea of applying the light to useful purposes, although the gas had been discovered and obtained both naturally and artificially more than half a century before.

Mr. Murdock at that time manufactured the gas in an iron retort, and conveyed it in pipes to the different rooms of his house, where it was burned at proper apertures or burners. Portions of the gas were also confined in portable vessels of tinned iron and other materials, from which it was burned when required, forming a moveable gas light. He had a gas lantern in regular use, for the purpose of lighting himself home at night across the moors from the Mining Engines that he was erecting, to his house at Redruth. This lantern was formed by filling a bladder with gas, and fixing a jet to the mouthpiece of the bladder, which was attached to the bottom of a glass lantern, with the bladder hanging underneath.

After various experiments, by which he proved the economy and convenience of light so obtained, compared with that from oils, resinous, or animal substances, he perfected his apparatus, and made a public exhibition of it, by lighting up the front of Mr. Boulton's Manufactory, at Soho, on the occasion of the general illumination for the peace of Amiens, in 1802. He subsequently lighted up some Cotton Mills, at Manchester, beginning with that of Messrs. Phillips and Lee; and he published a paper describing the advantages in the Philosophical Transactions for 1808, for which the Royal Society presented him with their large Rumford Gold Medal.

The Retort first employed by Mr. Murdock was made of Cast-Iron, of a Cylindrical form, and of small size, placed vertically in a common portable furnace, as shewn in Fig. 3, Plate 15. The inconvenience of removing the coke from this vertical retort led to the adoption of a horizontal cylinder, as shewn in Fig. 4, which represents the retort used by Mr. Murdock in 1802: these retorts were of cast-iron, from 12 to 20 inches diameter, and

from 3 to 7 feet in length. Fig. 5 shews the form of retorts that he first used at Messrs. Phillips and Lee's Mills, it is nearly similar to the earliest form shewn in Fig. 3, but larger in size, holding 15 cwt. of coal, and an iron cage (A) was adopted to facilitate the discharge of the coke; this cage was let down into the retort previously to charging it with coal, and was afterwards lifted out by means of a small crane, when the process of distillation was completed, bringing out with it the whole of the coke.

Mr. Murdock also tried other forms of retorts, of which Fig. 6 is an example, having two openings in them, one at the top for charging it with coal, and another at the bottom for withdrawing the coke; but these were found to be more expensive in cost and working, and he adhered ultimately to the simple horizontal retort, Fig. 4, which came into general use, and continued so, with little alteration in principle up to the present time.

His experiments also led him to increase the intensity of the heat employed, and the rapidity of the process of distilling the gas, as he found from his long-continued experiments that he obtained a greater quantity of gas from the same quantity of coal with less liquid product and coke, and a greater illuminating power of the gas, when the retorts were heated to a bright red heat, than at any lower or higher temperature.

Mr. Murdock took out a patent in 1810 for boring Stone Pipes for Water, and cutting Columns out of solid blocks of stone. Instead of boring out the whole inside contents of the pipe, a solid cylindrical core of ½ inch less diameter than the inside of the intended pipe, is cut out of the centre of the block of stone by a cylindrical crown saw; or a column is formed by a similar process of cutting it out in its finished form from the centre of the block, leaving the rest of the stone in the form of a pipe; the cores of the larger pipes being available for columns, thus effecting a saving of labour and material.

The apparatus consisted of a thin iron cyliner of the size required, having an iron or copper ring forming the circular saw fixed at the bottom either smooth or with saw teeth, and the

head of the cylinder slides down a verticle spindle with a feather fitting a groove in the spindle to prevent it turning round. The cylinder is supported by a cord or chain attached to the head, and passing up through a hole along the centre of the spindle, which is hollow at the upper part. This cord is carried over a pulley, and by this means the cylinder is lowered as the saw advances, and the saw is pressed down by weights placed on the head. The cylinder is driven round with a reciprocating rotative motion, by a rope I passing round a pulley fixed on the top of the spindle, and pulled alternately by a man at each end or by other power.

A stream of water or sand is poured regularly into the top of the cylinder from a trough to supply the saw, and the water rising to a head in the interior of the cylinder forces its way under the bottom of the saw, and rises up outside the cylinder, overflowing at the top, and thus continually clears the saw by washing away the sand and grit, and carrying it up the groove cut in the stone; when the depth of the bore exceeded 6 or 7 feet a readier outlet for the water and the sand was made by boring a small hole in the side of the pipe, which was afterwards plugged up.

A Machine was constructed at Soho Foundry on this plan, where it was set to work, and also at Mr. Rennie's Works in London: the first pipe bored was of marble, and proved quite successful. The patent was subsequently sold to a Company in London, with the object of supplying water of greater purity, by conducting it through stone instead of iron pipes, which scheme was ultimately abandoned.

Mr. Murdock in 1802 applied the compressed Air of the Blast Engine employed to blow the cupolas at the Soho Foundry, for the purpose of driving the lathe in the pattern shop, by using it to work a small Engine with a 12 inch cylinder and 18 inch stroke, which was connected to the lathe, the speed being regulated as required by varying the admission of the blast. This engine continued in effective use for about 35 years, and

as only discontinued on the occasion of an alteration of the shop.

He also constructed a Lift worked by compressed air, for the rpose of raising and lowering the castings from the boring ll to the level of the Foundry and Canal bank, which continued constant use for about 30 years, and consisted of a piston rking in a cylinder 10 feet diameter in water, with a lift of 12 t, and raised by forcing in air from a small blowing cylinder inches diameter, 18 inches stroke, which was worked by the ring in the boring mill.

Mr. Murdock also applied compressed air to ring the bells in house. A small brass cylinder, 1 inch diameter, was fixed ainst the wall of his rooms, having a piston in it, with an iron ob at the top, and a $\frac{3}{8}$-inch tube was carried from the bottom the cylinder to the bell, terminating in a similar cylinder and ton with a clapper projecting from it, which struck the bell en the piston was driven outwards by the first piston being shed down; he had a range of them communicating with the ms in his house, and these are still in existence, after having rked satisfactorily for 35 years. Sir Walter Scott having once ard a description of them, was so much pleased with the plan, at he had his own house at Abbotsford fitted up in a similar nner.

An accidental circumstance that Mr. Murdock observed of me iron borings and sal-ammoniac getting mixed together in tool chest, and rusting his saw blade nearly through, led to e invention of the Cast-Iron Cement, that has since become so iversal and important an assistance in the construction of gines and machinery, and became a very extensive manufacture the Soho Works.

He made several experiments on the projectile power of High-essure Steam, and a specimen has been preserved of a lead ll that he fired from a Steam Gun against the wall of the Soho undry; this ball is now laid before the meeting, it is $1\frac{1}{4}$ inch ameter, and it bears the date of the experiment 1803 engraved on it.

So completely was he absorbed at all times with the subje
he had in hand, that he was regardless of everything else. Wh
in London explaining to the Brewers the nature of his subs
tute for Isinglass, he occupied very handsome apartments; h
however, little respected the splendour of his drawing-room, an
fancying himself in his Laboratory at Soho, proceeded with h
experiments quite careless and unconscious of the mischief h
was doing.

One morning his landlady calling in to receive his orders, w
horrified to see all her magnificent paper-hangings covered wi
wet fish skins hung up to dry; and he was caught in the fact
pinning up a cod's skin to undergo the same process. Wheth
the lady fainted or not is not on record, but the immediate eje
ment of the gentleman and his fish was the consequence.

In the year 1815 Mr. Murdock erected an Apparatus of h
own invention, for heating the Water for the Baths at Leamin
ton, by a circulation of Water through pipes from a boiler,
process since adopted extensively for heating Buildings. Th
first building heated in this way was the conservatory of his so
at Handsworth; the apparatus of which he erected about th
same time, and it remains in use to the present day. Th
heated water is conducted around the conservatory by a pi
leading from the top of the boiler, which returns to the boile
and delivers the cold water in at the bottom; the hot water b
its diminished specific gravity rises to the top, and its place
occupied by the cold water rushing in at the bottom, and th
current is increased as more heat is applied to the boiler, actin
on this principle a rapid current is soon obtained through th
pipes.

During the erection of the apparatus at Leamington, M
Murdock met with a severe accident, which for some tim
threatened to prove fatal; a ponderous cast-iron plate fell upo
his leg above his ankle, and nearly severed the lower part of th
leg. The severe injury he received confined him a long time
Leamington, when it was thought safe to remove him, as h

ld not bear the motion of a carriage the Committee of the mingham Canal Co. kindly placed their excursion boat at his posal, in which he was removed to Birmingham. The frac-e, however, was of so severe a nature that it was long before could walk, and indeed he never completely recovered from effects of it.

n his latter years his faculties, both corporeal and mental, erienced a gradual decay, and he lived in absolute retirement. died on the 15th November, 1839, aged 85 years, and his ains were accompanied by several old and attached friends, the Soho workmen, to their last abode in Handsworth rch, and are there deposited near those of Mr. Boulton and Watt. A Bust by Chantrey serves to perpetuate the remem-ice of his manly and intelligent features.

IR. BUCKLE exhibited to the meeting the original Locomo-, which had been lent for the purpose by Mr. Murdock's , Mr. John Murdock, of Handsworth, near Birmingham, the locomotive was set to work before the meeting.

IR. MIDDLETON, who in his youth had been for many years at o Foundry at the same time with Mr. Murdock, bore testi-ny to the correctness of many parts of the paper; and arked, that he had himself frequently worked the rotary ine up to the year 1814, when he left the establishment. observed, that Mr. Murdock was intitled to the credit of in-ting the pneumatic lift, and he thought the one which had en recently brought before the Institution by Mr. Gibbons s due to Mr. Murdock, who had supplied the particulars of lift at Soho Foundry, and the designs for another construc-n of lift working with a revolving drum.

Mr. Slate, in the absence of Mr. Gibbons, observed, tha he thought there was an essential difference between the lif which had been previously described by him and that originall invented by Mr. Murdock.

The Chairman remarked, it was gratifying to observe th feeling of attachment which was so strong in the minds of a who had been connected with those who might be termed th patriarchs of mechanical engineering in this country. H might mention that it had been remarked to him as striking instance of the value of institutions like the presen that at the close of the last century, Watt, Boulton, Wedgwoo Murdock, Keir, Darwin, and Priestly, all eminent in som department of science, art, or enterprise, were connected wit the Lunar Society, held regularly for several years in Birming ham, the name of which was derived from the fact of thei meetings taking place at the occurrence of the full moon, a being the most convenient time for their returning home When they bore in mind the eminence which these men, individ ually attained, they could not fail to be struck with th advantages resulting from the interchange of mind with minc

The following paper, by Mr. W. A. Adams, of Birminghan was then read :—

ON RAILWAY CARRYING STOCK.

The object of the present paper is to discuss and analyse th various descriptions of Railway Carrying Stock, with the purpos of suggesting such improvements in the details of form an manufacture as will materially reduce the gross or dead weigh of the vehicles, without affecting their efficiency or strength.

This matter has been brought prominently under the writer' attention, from the fact that upon leading lines of railway th First Class Carriages for the conveyance of 18 passengers hav reached a gross weight of 5 tons, and Waggons for th

veyance of a maximum load of 5 tons, have reached a gross ight of $4\frac{3}{4}$ tons. These it is to be observed are probably reme cases, but being modern they evidence the tendency ncrease the weight of trailing stock.

t is scarcely needful to remark that if a Locomotive engine is ble of conveying a train of 50 waggons weighing 200 tons the load 200 tons (which proportion will not be short of the h, even without taking empties into account), a saving of *one* in the weight of each waggon will enable the engine to con- 50 tons additional of waggons and load, or equal to a saving *ne-eight* in the cost of haulage.

n the important matter of Inland through coal traffic, the gon averaging 3 tons 15 cwt. carries 5 *tons* of coal. But as the gon of course returns empty for 5 tons of coal conveyed one , 7 tons 10 cwt. of waggon has been conveyed the same ance.

n this instance the saving *one ton* weight in the construction he waggon would be equivalent to a total saving of nearly *sixth* in the cost of haulage;—that is to say if the present s are remunerative the prices may be reduced 16 *per cent.*, icing a much more extensive traffic, and better enabling ways to compete with water conveyance.

nland coals are mostly conveyed in waggons belonging to the ieries, or rented to the collieries by private individuals. In er case the tonnage or mileage charges on the railways being spective of the weight of waggon; the object of the waggon ner is to produce such waggons as will be most durable with smallest amount of first cost. The weights of colliery wag- s have been gradually increasing, each new lot being made was recently observed by the manager of an extensive inland iery) of such a strength and weight, that in the event of a ision they may break their neighbours and remain uninjured mselves.

Engine and Carriage superintendence are generally distinct artments. The Carriage superintendent aims at the utmost

economy of maintenance in his department, and pro
carriages and waggons, which though very lasting and
serviceable, are meanwhile greatly increasing the expen
of the Locomotive department. It would appear that
case has the interest of the parties directly concerned be
decrease the weights of the vehicles.

The heavy trains handed over to the Locomotive depar
to haul, induced the construction of more powerful and wei
engines, until the maximum was quickly reached and c
by the sufferings of the permanent way. It is to be ob
that the writer has no desire to carry the question of
vehicles to any utopian extent, but simply to calmly stud
elucidate, by experience and experiment, the practical me
reducing the weights of vehicles within proper bounds.

At the period of the commencement of Railways pass
were mostly conveyed by four-horse coaches, light goods by
and heavy goods by water. It is the intention of the wri
this paper to confine the enquiry to wheel vehicles.

The great distinction between road and railway vehic
that railway vehicles have to sustain longitudinal strains
direction of the buffing, as well as lateral and perpend
blows.

The Four-horse Coach weighing 19 cwt., conveying 18 p
with Luggage, weighing in all 1 ton 7 cwt., at a rate of ten
per hour.

The Four-horse Brighton Van, weighing 1 ton 11 cwt.
veyed 6 tons of goods at a rate of four miles per hour.

Every pound was carefully saved in weight of constructi
the above vehicles. The timber was carefully selected E
ash; not that ash was the most lasting and durable, but
for strength and toughness, it was unequalled in ligh
though short in its period of duration.

The axles and the iron-work were wholly made of the
marks of scrap iron. Skilled and costly labour of a high
was employed in the forging and fitting of the iron-work

ion of the wood-work. In all cases where extreme required, the timber was carefully plated with iron; e utmost strength with the smallest amount of

ompeted, not so much in price but as artists, to roportion of parts and materials the utmost result t weight. The gradients were bad, the roads imper- ve power limited. The wear and tear of the carriage lry consideration to the cost of hauling power. The e probably as near perfection as man's ingenuity e them.

ous with the Four-horse Coach and Van, was the f Coals upon Tramyways with Horse-power.

r will confine his observations to that district e is practically acquainted, that of Monmouthshire. the making of the Sirhowy and the Monmouth- ys, a total length, exclusive of branches, of 26 miles nes and iron works to the shipping port of Newport, l in the 42nd of George 3rd, and consequently 48 nd that Tramway has been worked until within the onths by horse-power.

it was a tramway with fish-bellied cast-iron plates ted upon stone blocks, with 6 feet bearings. These ly given place to rolled plates of malleable iron, ut 80 lbs. to the yard, and laid in chairs upon cross s with 2 feet 8 inch bearings.

ate 1 represents the class of waggon, or as it is d, *tram*, used upon this Tramway. The gross weight , and it carried 3 tons of coals at a rate of three ur, exclusive of the time consumed at the various s by the tramway side.

king or skidding down the inclines was effected in omplete manner by means of a slipper or shoe, hat of a stage coach, and the stopping of the train a bar of wood through the spokes of the wheel, or,

as it is locally termed, spragging the wheel. The unloading was effected by means of a gallows and crab, the tram being raised at one end, and the coals discharged by means of the swinging tail board at the other end.

It will be observed that no provision is made for buffing, but that the train is articulated by means of the hitching A shewn in the drawing. The wheels ran loose upon the axles, and were in most instances dished in the manner of a common road wheel, thereby illustrating the first advance from a common road vehicle.

The tramway is mostly an incline from the mines to the port. Six horses brought down 60 tons of coals and 16 tons of trams. The same power was required to take up the empty trams. Dead weight in the trams was consequently of vital inportance.

This tramway is now being worked with Locomotive power and permanent waggons, the Tramway Company finding power, and the freighters waggons. The same care, which influenced the private haulier and caused him to equalize his upward to his downward load, does not now influence the freighter, and has been lost sight of by the Company. In the eye of the freighter the waggon which is strongest and heaviest is the best, and the consequence is, that waggons weighing 3 tons are conveying but 5 tons of load.

The ratio of upward load was in the one case 21 per cent. and in the latter 37 per cent., as compared with the downward.

The weight of waggon conveyed up hill, was in the one case 27 per cent., and in the latter 60 per cent., as compared with the coals brought down.

In place of a perfect horse tram-road heavy engines are being hammered, and are hammering to pieces a bad road with bad gradients and extremely bad curves. This is wholly true, but fortunately an extreme case; nevertheless it is questionable whether many lines are not also suffering in a lesser degree from the incubus of dead weight.

The Huntingdon and St. Ives's branch of the East Anglian Railway, $4\frac{3}{4}$ miles in length, is at the present time worked by a

se Carriage. This Carriage is a composite carriage con-ing of three compartments, and carrying 60 passengers in all, de and out.

t is to be observed that the carriage is made from an ordinary posite, the under frame being completely taken away, and els, guards, and springs of the lightest construction tituted. The total weight is 3 tons, but the weight would exceed 2 tons, if the carriage had been originally built for present purpose. The horse is attached by an outrigger, which the traces are hooked, and he travels by the side of carriage, with his head tied up to the carriage to prevent him turning round. A break is applied to the wheels.

he writer has instanced this carriage to illustrate that when e-power is brought into use the weight of vehicle is at once idered; and also that the vehicle being used singly does not ire strength to resist longitudinal buffing. The cost of king this carriage is sixpence per mile, including horse driver, and the guard, who is also ticket collector.

he pace is ten miles per hour, and it would appear that this lication meets all the requirements of the limited traffic of a t branch.

Rapid strides were made by Engineers in perfecting the way the locomotive. The facts relative to the Permanent-way e been discussed and appreciated, and the details greatly fected. Locomotives have been improved, the consumption fuel brought probably nearly to the minimun; the details e been understood, discussed, and experimented upon by n of high talent and experience.

But far differently with the matter of the Carrying Stock. construction of the carriage and the waggon was in the mencement left wholly to men of long practice in carriage lding for the common road, but not experienced in mechani-engineering.

Those patterns originally set, have been copied and re-copied an almost servile manner. When carriages and waggons

have failed in their parts, the sole remedy has been increase of strength by increasing the weight and quantity of material. Axles have increased from 3 inches diameter to 4 inches; tyres from $4\frac{1}{2} + 1\frac{1}{4}$ inches to $5 + 1\frac{3}{4}$ inches, and so throughout.

Fig. 3, Plate 1, illustrates the original London and Birmingham and Grand Junction First Class Carriages, with three compartments, carrying 18 passengers.

Dead Weight $3\frac{1}{4}$ tons.

Cubical contents 504 feet.

Fig. 4, Plate 1, illustrates the modern First Class Carriage, with 3 compartments, carrying 18 passengers.

Dead Weight 5 tons.

Cubical contents 807 feet.

The dead weight of waggon, per ton of load, for the upward and downward Journey of the—

Old Monmouthshire Train, $\frac{1}{2}$ ton.

New Monmouthshire Waggon, $1\frac{1}{5}$ ton.

Derbyshire and Leicestershire Coal Waggon, $1\frac{1}{2}$ ton.

The writer presumes that it will be at once admitted that reducing the dead weight of railway vehicles is extremely desirable, whilst such reduction of weight is effected with due regard to efficiency and strength to resist the longitudinal strain in buffing. Also that reduction in first cost is not the sole object to be attained, but to produce such vehicles as shall be, all points considered, the most economical in first cost, in maintenance, and especially in traction; but at the same time it does not follow that reducing the dead weight and improving the quality of the materials shall add materially, if any, to the cost.

Should it be approved by the Institution, the subject of a second paper will be to analyse and compare the whole of the modern trailing stock with that of an earlier period, and thereby glean such information as will enable the writer to prepare and lay before the Institution, in a future paper, such improvements in the form and manufacture of railway vehicles as may lead to the result pointed out at the commencement.

It is proposed to try all necessary experiments as to the elative strength of wood and iron, and the combination thereof, n order to obtain the necessary information as to the most ligible and económical means of attaining the greatest strength ith the least weight.

The CHAIRMAN observed, that the paper was one of great portance, but as their time was expired, unless some member d any communication to make, it was better that the discusn should be adjourned to the next meeting. He might serve that it was principally at his suggestion that the paper d been prepared, considering that nothing could well exceed importance of getting rid of any unnecessary dead weight; d he hoped, that in the interval between the present time and ir next meeting, the subject would receive the serious attenn and consideration of the members.

He announced that a proof copy of the valuable work on the itannia Bridge had been presented to the institution by the esident; also that Messrs. Fox, Henderson, and Co., had esented a proof copy of their engraving of the Building for Great Exhibition in 1851.

MR. GEACH called the attention of the members to the bscription now in progress for the erection of a monument or testimonial, on an adequate scale to their late respected esident, George Stephenson. The proposal, which originated th the members of the Institution, had been very favourably ceived in influential quarters; and he was anxious that witht delay such members of the Institution as sympathized with e object would communicate to the Secretary what sums it s their wish to contribute. Already they had received

promises of several amounts of £100 each, but prior to t publication of the first subscription list it was desirable that t sums should partake of a miscellaneous character so that whi many might be disposed to subscribe largely, others might n be prevented from joining by the fear of giving too litt He had no doubt that a considerable sum would be raised, b it was particularly desirable that the list should contain as ma names as possible—and the shilling of the honest intellige mechanic would be received with as great pleasure as the larg contribution of the more wealthy.

The meeting then terminated, and the members adjourned the Library of the Institution, where coffee was provided.

RAILWAY AXLES.

Plate 1.

Fig 1.

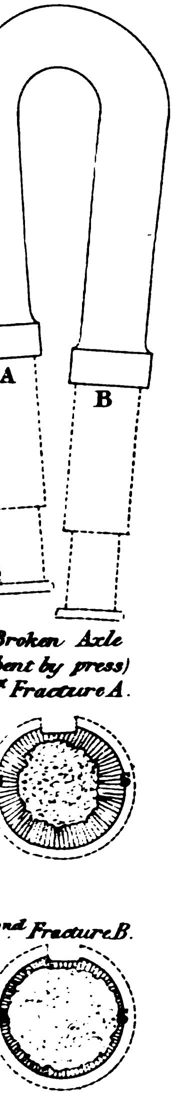
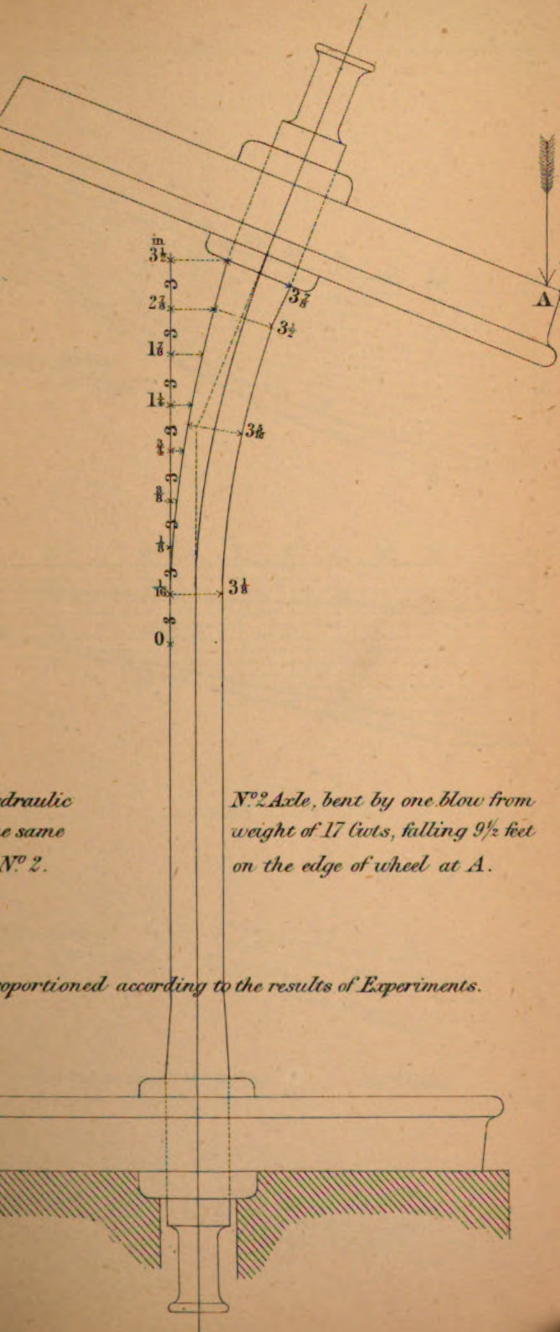


Fig 2.



...draulic
...e same
Nº 2.

Nº 2 Axle, bent by one blow from weight of 17 Cwts, falling 9½ feet on the edge of wheel at A.

...oportioned according to the results of Experiments.

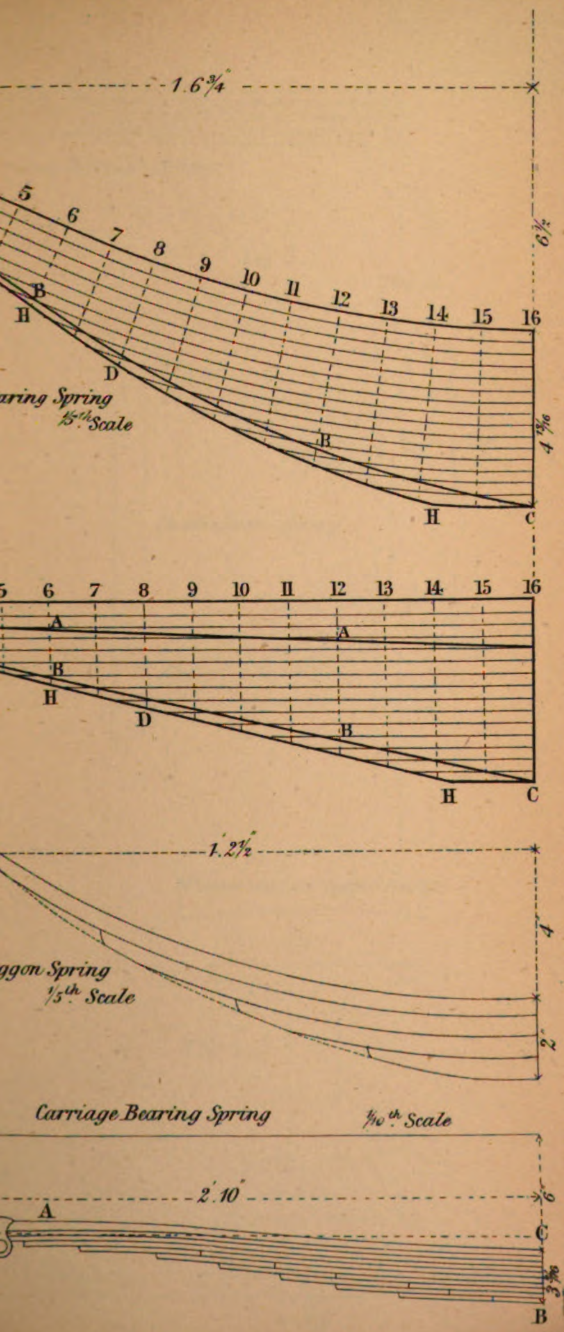
ERS.

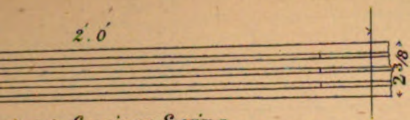
S

, 1851.

DENT,

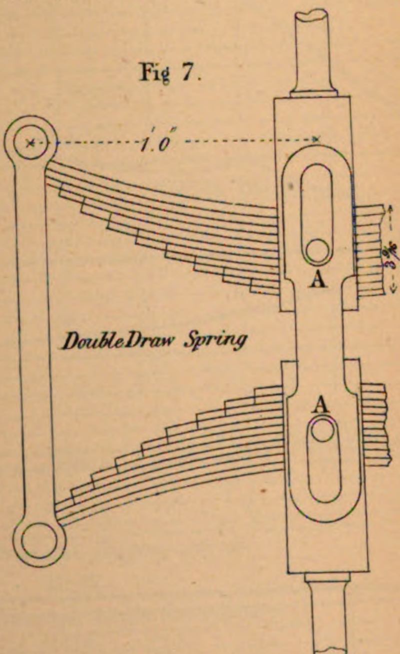
WALL.


1.6¾"
5
6
7
8
9
10
11
12
13
14
15
16
6½"
B
H
D
aring Spring
1/5th Scale
B
4 13/16
H
C
A
A
B
H
D
B
H
C
1.2½"
4"
ggon Spring
1/5th Scale
2"
Carriage Bearing Spring
1/10th Scale
2.10"
6"
A
C
B

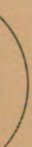


anan's Carriage Spring

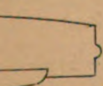
Fig 7.



Double Draw Spring

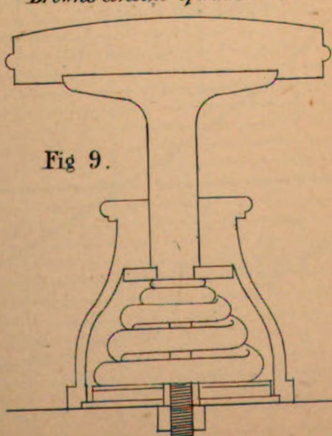


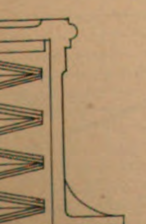
ffer.



Brown's Conical-Spiral Buffer.

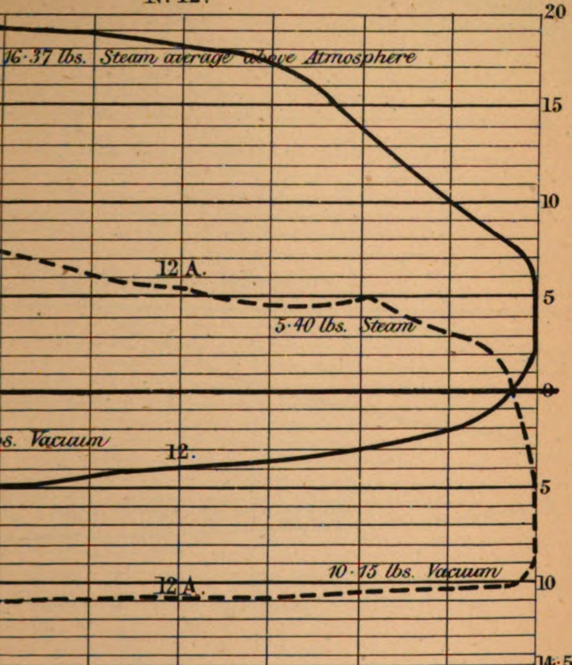
Fig 9.





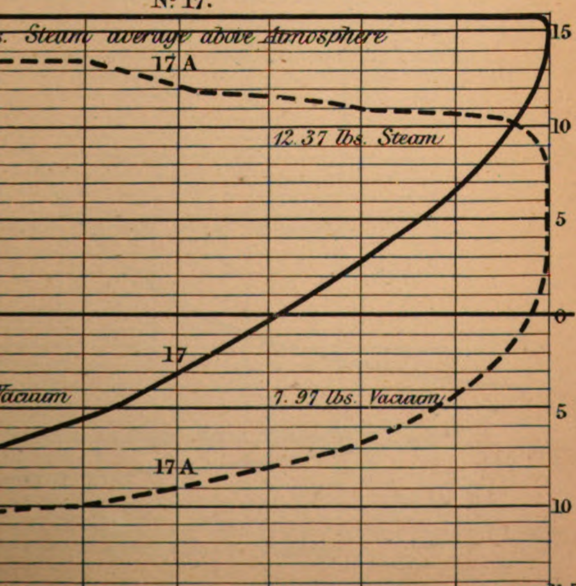
ize.

Nº 12.



Diagrams from Mill Engine altered.

Nº 17.



iagrams from Mill & Forge Engine altered.

N° 45.

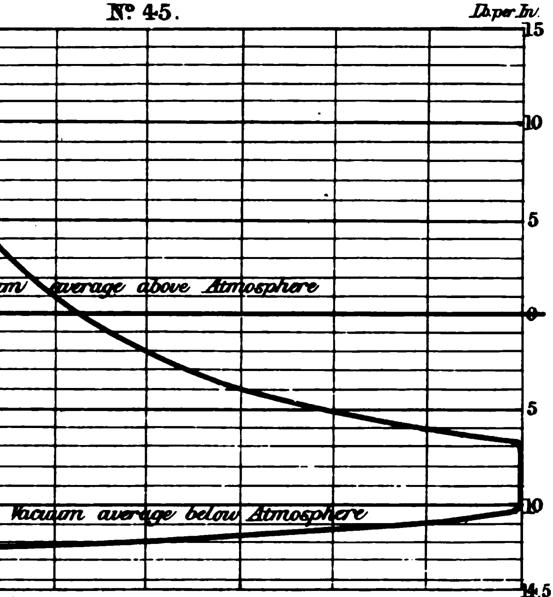


Diagram from Factory Engine.

N° 47.

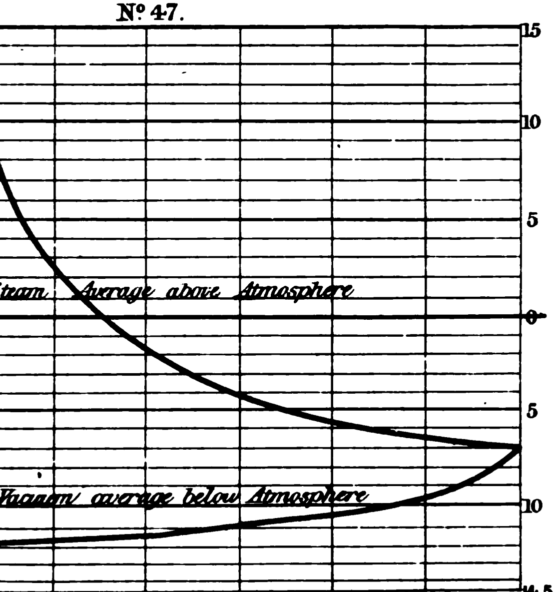
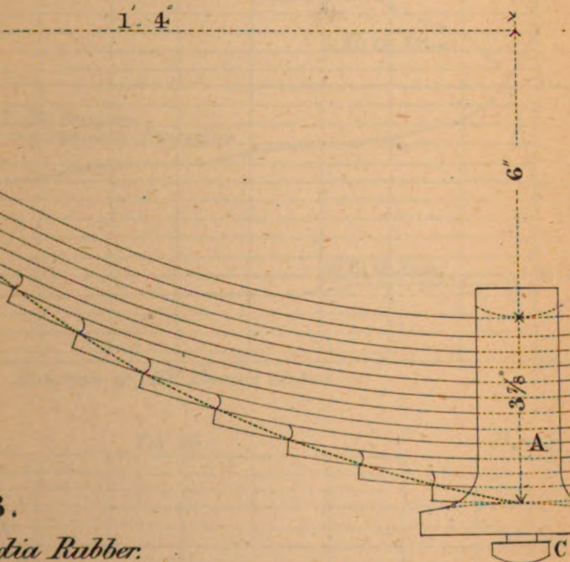


Diagram from Blast Engine.

...ved Waggon Bearing Spring. *1/4th Scale*

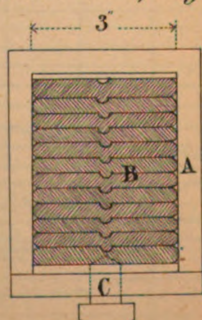


...3.

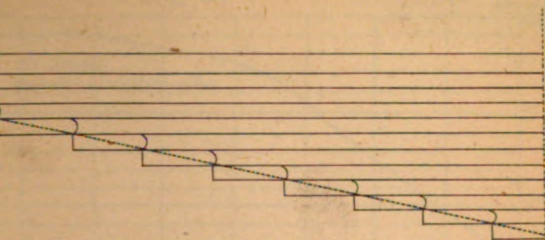
...dia Rubber.

Fig. 12.

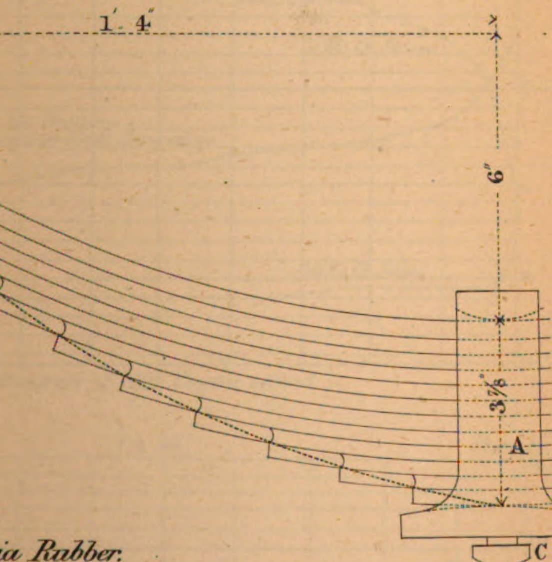
Section of Spring.



Scale 1/4th siz...



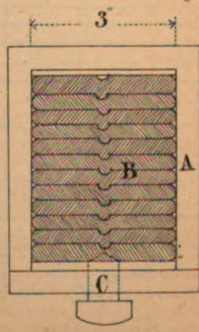
d Waggon Bearing Spring. *1/4th Scale*



ia Rubber.

Fig. 12.

Section of Spring.



Scale 1/4th size.

Fig. 12.

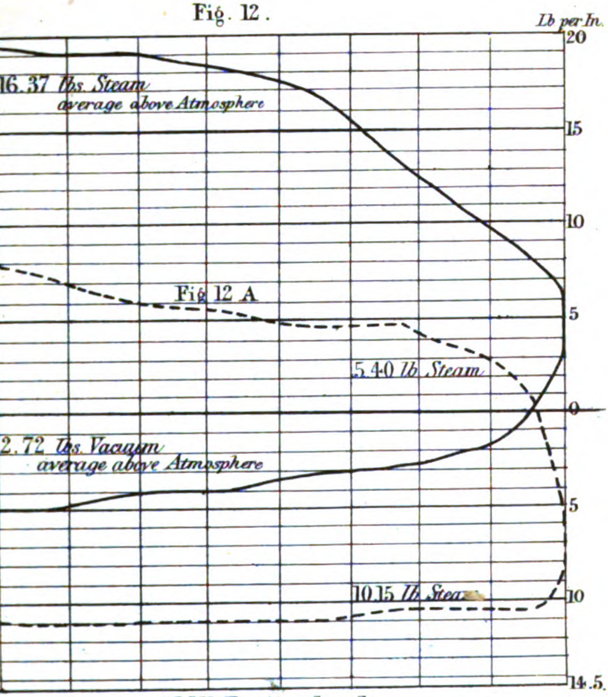


Diagram of Mill Engine altered

Fig 46.

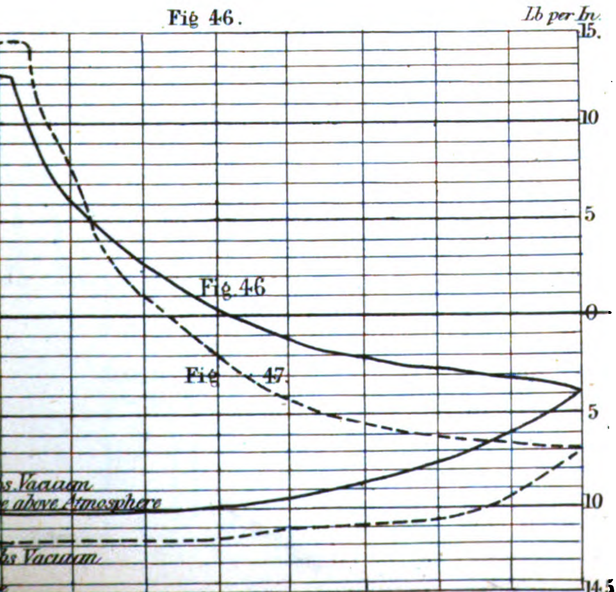
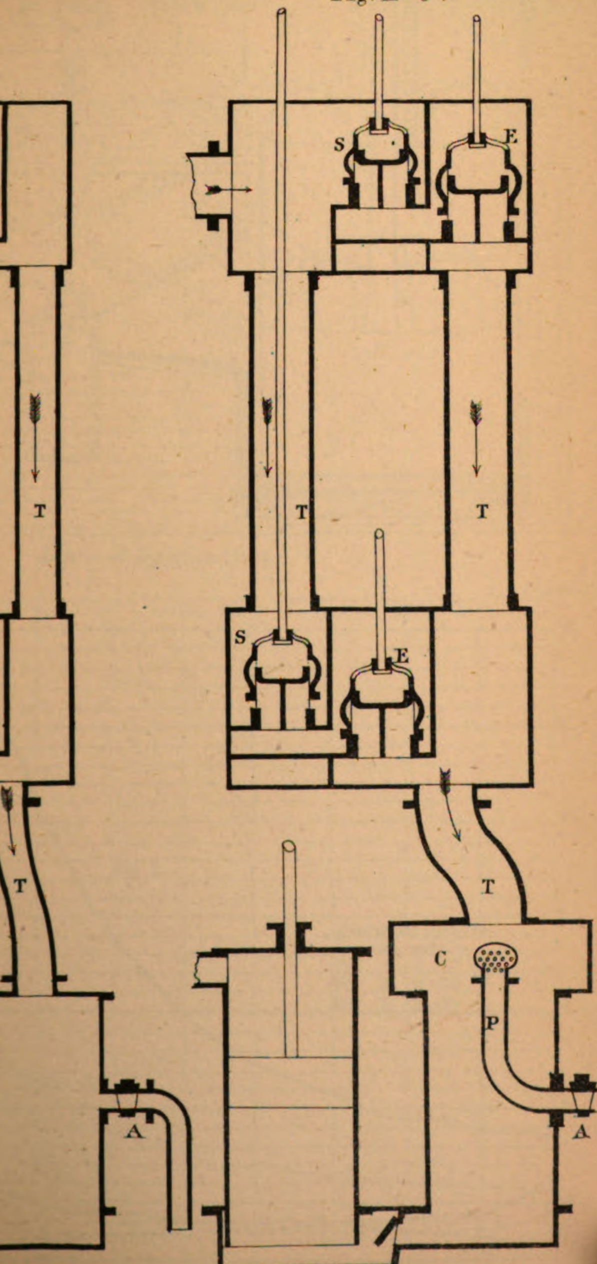


Diagram from pair of Blast Engines.

Fig. 12 C.

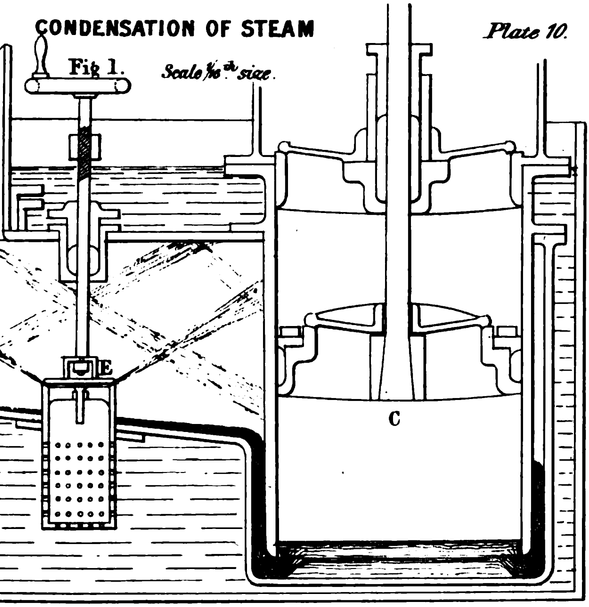


Scale 1/10th size.

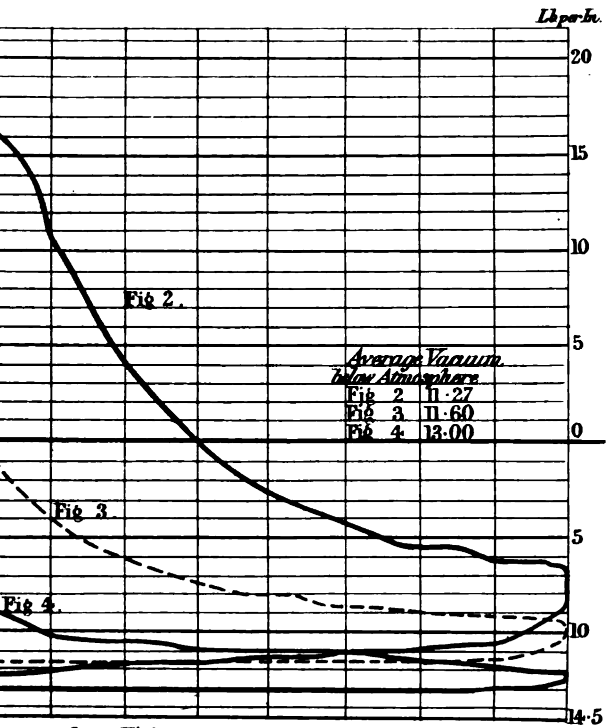
CONDENSATION OF STEAM

Plate 10.

Fig 1. *Scale 1/16th size.*



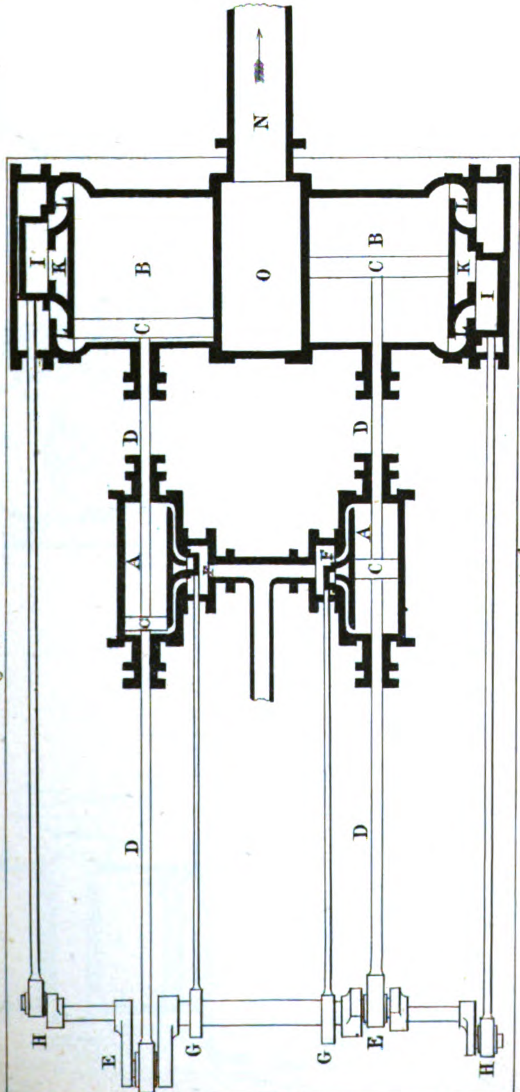
Improved Injection Valve



...gram from High-pressure Expanding &

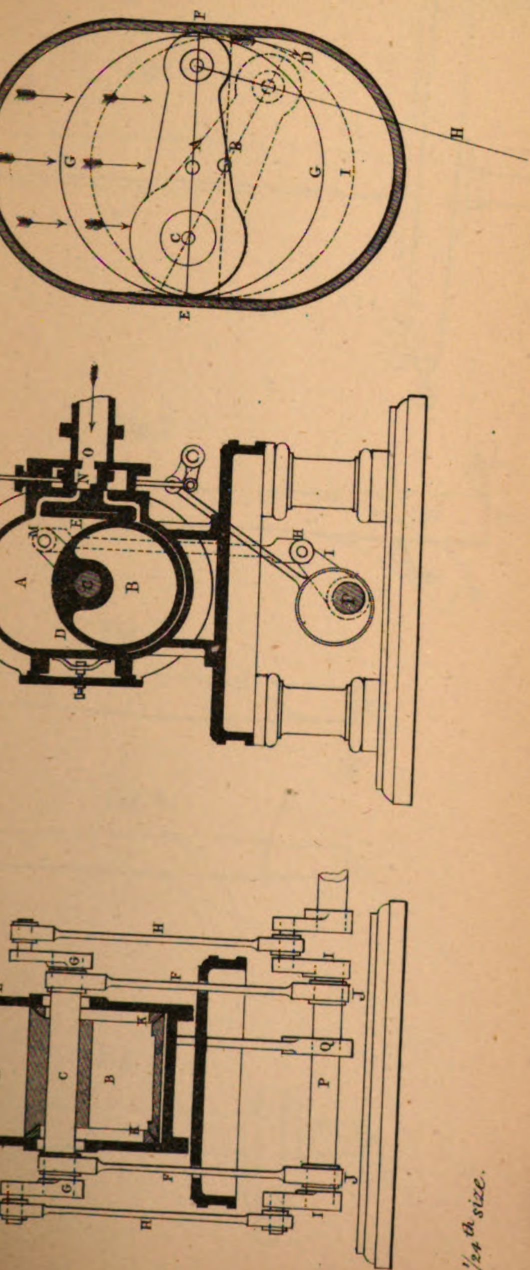
BLOWING ENGINE. *Plate 11.*

Fig 2.



Scale 1/40th size

RECIPROCATING STEAM ENGINE. *Plate 12*



Scale 1/24 th size.

Fig. 1.

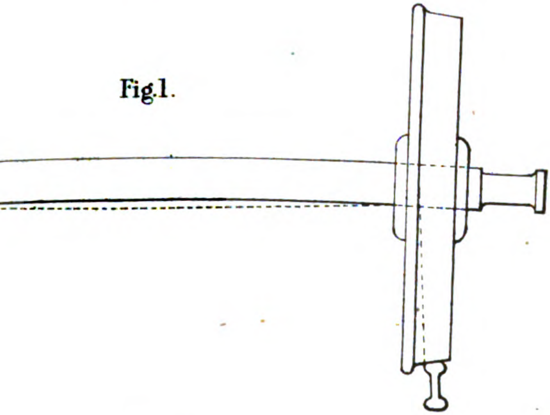


Fig. 2.

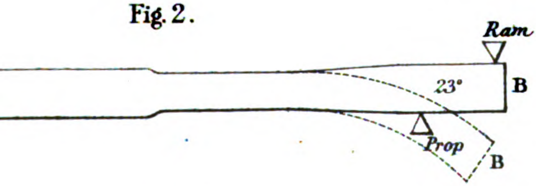


Fig. 3.

Fig. 4.

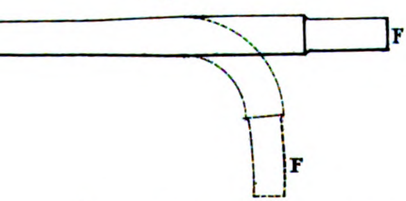
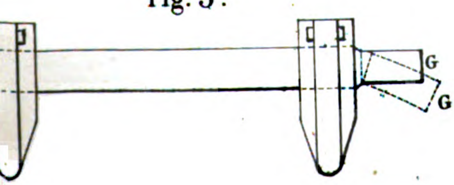


Fig. 5.



Scale 1/20th size.

Fig. 1.

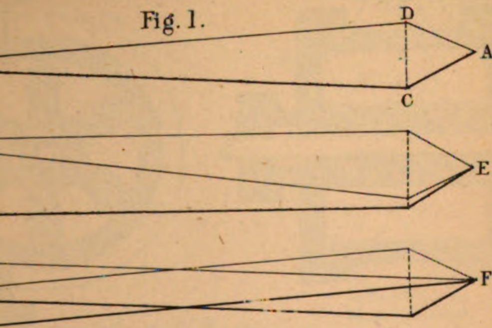


Fig. 2.

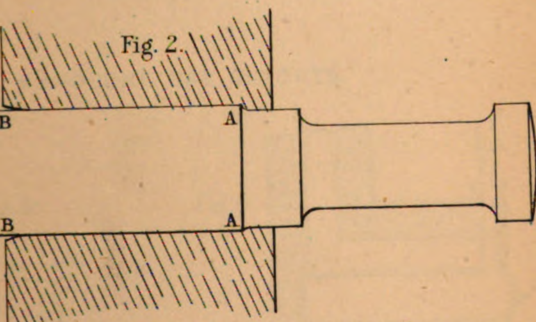


Fig. 3.

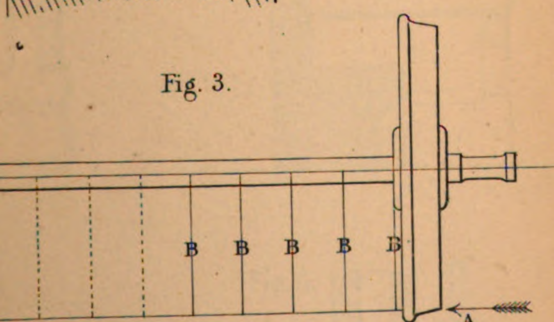
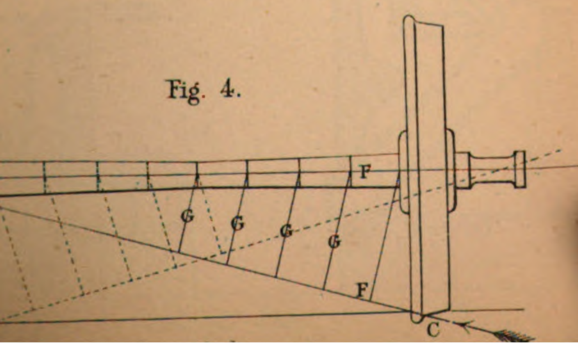


Fig. 4.



MURDOCK'S ROTARY ENGINE.

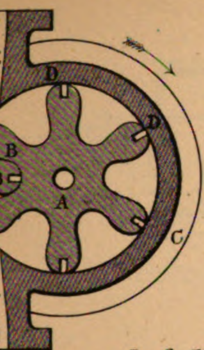
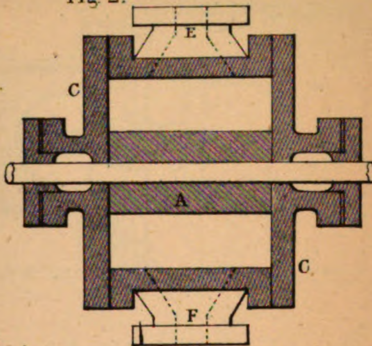


Fig. 2.



Scale 1/5th size.

MURDOCK'S GAS RETORTS.

Fig. 3.

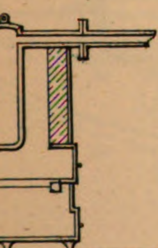
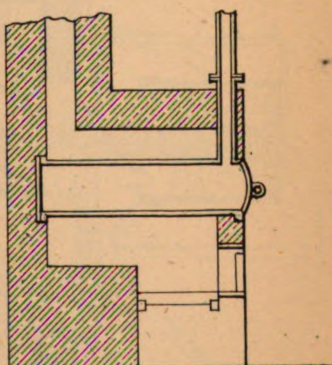


Fig. 4.



5.

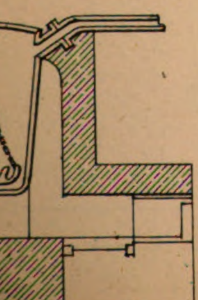
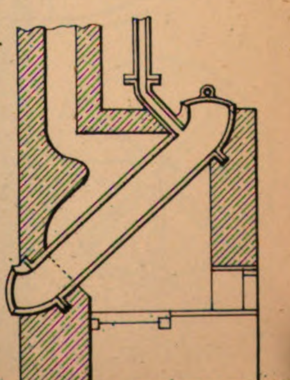


Fig. 6.



Scale 1/40th size.

Fig 1.

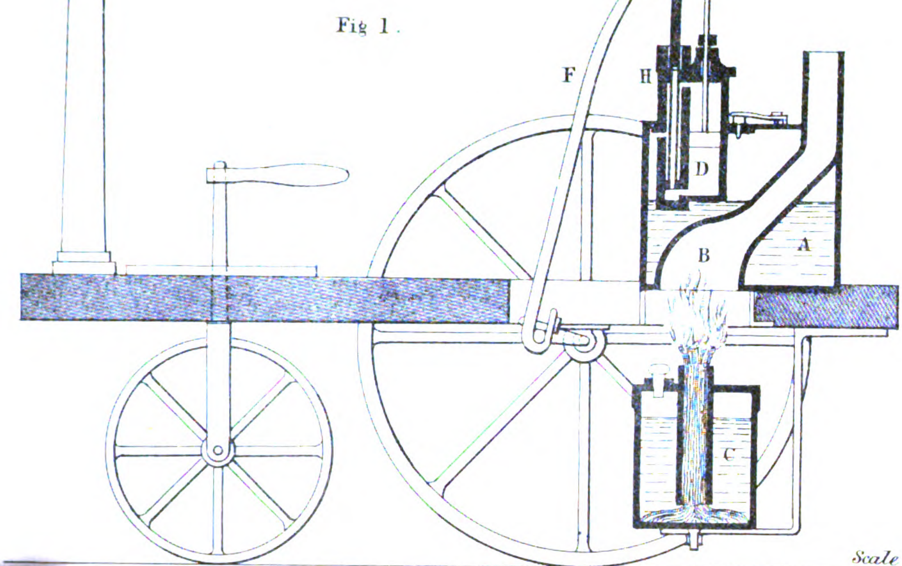


Fig 2.

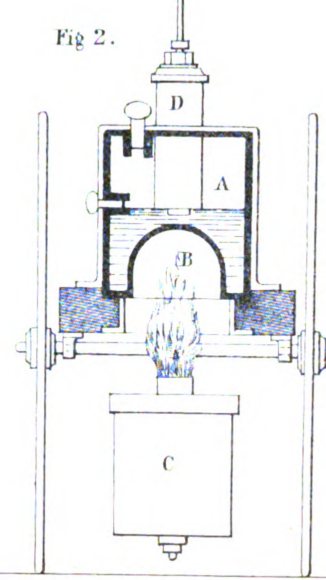
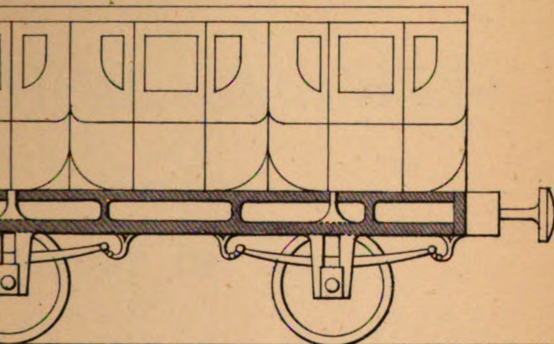
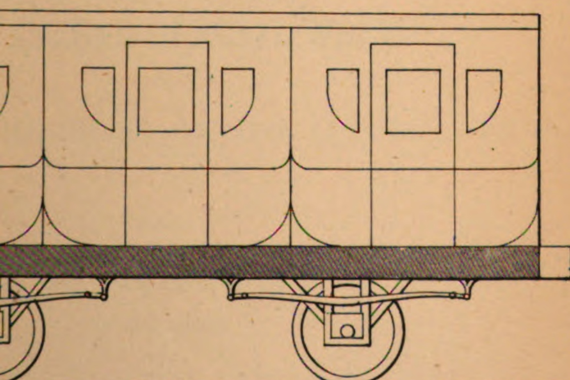


Plate 16

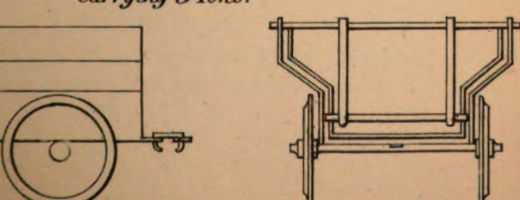
Original First Class Carriage,
Dead weight $3\frac{1}{4}$ Tons,
Carrying 18 Passengers.



Modern First Class Carriage,
Dead weight $5\frac{1}{10}$ Tons,
Carrying 18 Passengers.



Monmouthshire Tram,
Dead weight 16 Cwt,
Carrying 3 Tons.



Scale $\frac{1}{60}$th size.

INSTITUTION

OF

ANICAL ENGINEERS.

REPORT OF THE

OCEEDINGS

AT THE

I ANNUAL GENERAL MEETING,

RMINGHAM, ON 23RD JANUARY, 1851.

. E. McCONNELL, ESQ., V.P.,

IN THE CHAIR.

BIRMINGHAM:
D AT M. BILLING'S STEAM PRESS OFFICES,
74, 75, & 76, NEWHALL STREET.

1851.

PROCEEDINGS.

h Annual General Meeting of the Members
House of the Institution, Newhall Street, Bir-
dnesday, January 22, 1851 ; J. E. McConnell,
lent, in the Chair.

of the last General Meeting were read by the
nfirmed.

ary then read the following :—

EPORT OF THE COUNCIL,

TH ANNUAL MEETING, 22ND JANUARY, 1851.

l congratulate the Members on the satisfactory
nstitution at the present Fourth Anniversary of
, and on its continued and successful progress
usefulness.

r of Members for the last year is 202, of whom
Members, and 3 Graduates ; the class of Gra-
specially formed to enable the young and rising
profession to obtain the advantages which the
well calculated to afford.

al statement of the affairs of the Institution for
31st December, 1850, shows a Balance in the
of £230 3*s*. 0*d*., after the payment of all accounts
and this Balance has been further increased to
he receipt since 31st December of some subscrip-
last year, 1850. The Finance Committee have
ecked all the receipts and payments of the Insti-
ar 1850, and have reported that the following
endered by the Treasurer, is correct.

(See Balance Sheet appended.)

The Offices of the Institution have been established in the present building, containing the accommodation for the Meeting Room and Library, and for the Secretary to be resident on the premises, and affording additional facilities for promoting the usefulness of the Institution, and its efficiency in accomplishing the objects for which it was established. The Council hope to receive from the Members and their friends contributions of Books and Drawings, for the formation of a Library of reference, and Models of Machinery, &c., to form a Museum of Mechanical Models, for the use of the Institution.

The Council have the pleasure of announcing that the following donations to the funds and the library of the Institution, have been received during the past year.

Donation of £100 from the President, Mr. Robert Stephenson.
Proof copy of Work on the Britannia and Conway Tubular Bridges, from Mr. Robert Stephenson.
Paul R. Hodge on the Principles and Practical Application of the Expansive Steam Engine, from the Author.
W. Lee's Tables of the Strength and Deflection of Timber, from the Author.
F. Galton on the Telotype or Printing Electric Telegraph, from the Author.
W. Spence on Patentable Invention, from the Author.
The Mechanic's Magazine, from the Editor.
The Practical Mechanic's Journal, from the Editor.
The Civil Engineer and Architect's Journal, from the Editor.
The Artizan, from the Editor.
The Engineer and Machinist, from the Editor.
The Mining Journal, from the Editor.
The London Journal of Arts, from the Editor.
The Patent Journal, from the Editor.
Proof Engraving of the Building for the Exhibition of 1851, from Messrs. Fox, Henderson, and Co.

Amongst the communications and discussions at the Meetings of the Institution, during the last year, the Council have

ferring to the following as valuable and interest-
nprovement and economy, and to the advance-
ledge of the form and strength of materials.

sation of Steam in the Engines of the South
shire Iron District, and the Improvements to be
in them.
ruction of Blowing Engine for Blast Furnaces,
at high velocities.
ruction of Reciprocating Steam Engine.
d the Deterioration of Railway Axles.
nd Construction of Railway Carriage and Wag-
ings.
ment of the Construction of Railway Carrying

ons and Life of the late William Murdock, of

wish to draw the particular attention of the
nportance of giving all the assistance in their
the objects and increase the utility of the Insti-
munication of Papers with Drawings and Models,
inventions or improvements that have been
have come under their observation, and the
ents, and of the practical working of old or new
es, &c., with Indicator Cards from Steam En-
der the Institution a general place for reference
bjects. A list of proposed Subjects for Papers
the Council invite communications from all the
ir friends on these and any other Engineering
be useful and interesting to the Institution,
receive a further increase of the papers, so as to
r of the meetings; they trust that no members
ir communications on account of the want of
ake them so complete and lengthened as they
is one of the first objects of the Institution to
facts relating to the professional experience of
d to procure early and authentic information

respecting new mechanical inventions and improvements, for
mutual information and advantage of the members.

In the ensuing year an excellent opportunity will be affor
by the concourse of visitors from all foreign countries at the Gr
Exhibition in London, to open communication with fore
Engineering Societies for mutual advantage and the interchange
Transactions; and in furtherance of this object it would be
visable to obtain corresponding Members of the Institution
various countries, and the Council also recommend this opp
tunity to be taken for holding a Meeting of the Institution
London.

The Officers of the Institution and Five of the Member
the Council go out of office this day, according to the Rules,
the ballot will be taken at the present meeting for the election
the Officers, &c., for the ensuing year.

The CHAIRMAN observed, that all the members must
great satisfaction in the rise and progress of the Institution
Mechanical Engineers; he congratulated them on the proc
ings of the last year, and the excellent papers that had
brought before them, comprising questions of great practical va
and on the favourable prospect of papers for the ensuing year,
he thought there was no doubt that the important occasion of
great Industrial Meeting in London, when Engineers from e
country in the world would meet together, would also stimu
the Members of this Institution, in producing for that pe
some papers of importance and value.

He believed that a great deal of good might be done
establishing a connexion with foreign Engineering Societies;
had the pleasure recently of meeting the President of the Fre
Institution of Engineers, and of finding that shortly after t
last meeting he was in possession of their report, and he spoke
high terms of the usefulness of the Institution, and the valua
practical character of the papers. He thought it would be wel
establish a system of intercommunication with Foreign Engin
ing and Mechanical Societies, thus leading to an interchange

cal suggestions thrown out by the respective
to the establishment of that friendly feeling
t between the members of the profession, in
m visiting their respective countries, and cer-
was an auspicious era for bringing about so

on into the Institution of young and rising
fession, in the capacity of Graduates, he felt
ant aid to the future success and prosperity of
heir introduction into the Institution they would
with the principles of the system on which it
would take an increasing interest in it, and
l addition. A young engineer entering an
present, listening to the discussion on the
ought before them, might have his mind
emark, which, as frequently occurred, might
ractical result of importance and advantage;
t class of active, intelligent minds they could
Institution, the greater the practical results
ed that every head of an Establishment who
ience any young member of the profession,
ould form a useful graduate, would use his
to bring him amongst them: he should even
umber of these graduates equal with that of
Institution. In conclusion, he congratulated
the successful issue of their proceedings up
and he hoped that the Institution would go on
ness and efficiency.
of Mr. Williams, seconded by Mr. Buckle,
ved and adopted.
moved a vote of thanks to the Council and
stitution, for their services during the past
was seconded by Mr. Dockray, and passed.
then announced, that the ballot lists had
Committee appointed for the purpose, and
rs and Members of Council elected for the

President:
Robert Stephenson, M.P., London.

Vice-Presidents:

Charles Beyer, Manchester.
J. E. McConnell, Wolverton.
John Penn, London.

Council:

E. A. Cowper, Birmingham.
Edward Humphrys, Woolwich.
Edward Jones, Bridgewater.
William A. Matthews, Sheffield.
Archibald Slate, Dudley.

(In addition to the ten Members of Council who continue in office from the last year.)

Treasurer:
Charles Geach, Birmingham.

Secretary:
William P. Marshall, Birmingham.

The Chairman announced that the following new Members were also elected.

Members:

S. Holden Blackwell, Dudley.
George Downing, Smethwick.
John Rhodes, Hull.
J.T. Woodhouse, Ashby-de-la-Zouch.

The Chairman said he was happy to announce that the subscriptions towards erecting the National Memorial to the late George Stephenson amounted already to £2320, and the Committee were very sanguine that something like double the amount would be realized.

Mr. Benjamin Gibbons observed, in reply to a remark made at the last Meeting, with reference to the invention of the Pneumatic Lift, that he had described at a former Meeting, (see Proceedings, July, 1849,) that Mr. Middleton was under a mistake in attributing it to the late Mr. Murdock, of Soho. At that time he (Mr. Gibbons) had an intention of altering his furnaces to increase their height, but met with a serious obstacle in the confined situation of the Works, the furnaces standing close to the canal towing path, which prevented the use of the usual inclined plane for raising the materials to the top of the furnaces. He then thought that the blast, with which the furnaces was blown,

e of for the purpose of the lift, and he asked
. Murdock on the subject, with whom he was
and who promised to give it his consideration.
ards, he was standing near the Dry Regulator,
(the blast being suddenly taken off the furnace),
f the regulator rose beyond its usual working
raised to the level which opened the escape
mmediately struck him that, if the cylinder were
piston would have continued to rise to the height
a piston loaded with 7 or 8 tons were thus
not 7 or 8 tons of iron-stone be raised by a
It was obvious, that the same thing would apply
ator, which being a cylinder open at the bottom,
nd the blast admitted beneath it, had the same
unless held down by bolts. He considered the
and more applicable under the circumstances;
3 feet, he had only to make his water regulator
it would take up any weight proportioned to
inder. Some time after this plan was resolved
ck sent him, on his return from Cornwall, a
be acted upon by the blast; it was a wheel
, with buckets like an over-shot water-wheel,
ght probably have been wound up by it; but
ater regulator was the exact thing required,
ot try Mr. Murdock's plan. He might men-
r. Murdock afterwards saw his application of
r, he said, that had that idea occurred to him
e suggested the water-wheel, for, added he,
er than mine." The plan has answered com-
es for which it was intended. All who had
r. Murdock's acquaintance, well knew with
laid open the stores of his mind to any one
n interest, and his ingenuity of mind, amenity
indness of character had established for him
Indeed, they had only to look around the
ey were assembled, and if it were not for one
overies (referring to the gas by which the room
would find themselves very much in the dark.

Mr. BUCKLE remarked, in the absence of Mr. Middl
that he had expressed to him his regret at any observation o
subject that he might have made under a mistake; wh
claimed for Mr. Murdock was the perfection of the blast e
whilst Mr. Gibbons had, it appeared, adapted the water reg
to the purpose of the lift. He also bore his testimony t
excellency of the plan adopted by Mr. Gibbons: he w
opinion it was a most excellent method of lift.

The following supplementary paper, by Mr. W. A. Adar
Birmingham, was then read:—

ON THE IMPROVEMENT OF THE CONSTRUCTIO RAILWAY CARRYING STOCK.

In the previous paper laid before the last meeting of t
stitution the great increase was pointed out that has graduall
made in the dead weight of the carrying stock in the g
practice of railways; that the First Class Carriages carryi
passengers have been increased in dead weight from 3¼ to
tons; and the Waggons carrying a maximum load of 5 ton
reached a dead weight of 4¾ tons; and that this great increase o
weight occasioned an important addition to the cost of loco
power for the nett load carried. If a Locomotive Engine is c
of conveying a train of 50 waggons, weighing 200 tons, and th
200 tons (which proportion of dead weight to load will not b
of the truth, even without taking empties into account), a sa
one ton in the dead weight of each waggon will enable the eng
convey 50 tons additional of waggons and load, or equal to a
of *one-eighth* in the cost of haulage.

In the important matter of inland through coal traffi
waggon averaging 3¾ tons carries 5 tons of coal; but as the w
has to return empty, for 5 tons of load conveyed one mile, 7
dead weight of waggon has to be conveyed the same distanc
this instance the saving of *one ton* weight in the construction
waggon would be equivalent to a total saving of nearly *one-si*
16 *per cent.* in the cost of haulage.

The great increase in dead weight has arisen from the in

en continually making in the quantity and weight of ma- oyed in the construction of railway carriages and wag- remedy for the failure of their different parts; that ing generally been solely increase of weight of material, eration of material or construction.

common road vehicles, where the motive power was road imperfect and gradients bad, the cost of hauling of so great importance, that every pound of weight was ved in the construction of the vehicles, by using only terials and construction to obtain the strength with the ; the durability being comparatively a secondary con- The Four-horse Coach, conveying 18 passengers, ly 1 ton, and the Van, conveying 6 tons of goods, out 1½ tons.

eat distinction between road and railway vehicles is, y vehicles have to sustain longitudinal strains in the the buffing, as well as lateral and perpendicular blows. on of the dead weight of railway vehicles is extremely hile such reduction of weight is effected with due regard and strength to resist the longitudinal strain in buffing, he other strains to which they are subjected. The ob- oduce such vehicles as shall be, all points considered, onomical in first cost, in maintenance, and especially in d at the same time it does not follow that reducing the t, and improving the quality of the materials, will add if any, to the cost.

ole-Bar is the most important part of the waggon under- resists the main force to which the waggon is subjected, longitudinal buffing, and also acts as a girder to carry on the springs. The ordinary wood sole-bar averages 12 inches deep, and 3½ to 5 inches thick. Although the rain is the end-way buffing, the vertical strength is re- e so much greater than the lateral strength, in conse- the sole-bar being strutted horizontally by the internal

riter has endeavoured to discover the best form to attain strength in wrought-iron with the least material, and certain whether the same strength can be attained with than the ordinary wood sole-bar.

Fig. 1 (Plate 18) is a section of the ordinary English oak s bar, of the average dimensions, 11 inches deep and 4½ inches th the length is 13 feet, and the total weight by actual prac 321 lbs.

The correct theoretical section for wrought-iron to answe same purpose with the least material, would appear to be a girder as shown in Fig. 2. But this cannot be practically ado as it would be next to impossible to manufacture, and it is nece that some practical form of rolled-iron be adopted, for economy simplicity of construction.

The main force to be resisted is the end way buffing, an the strongest form to resist end pressure with the least ma would be a tube (as shown dotted in Fig. 3), that section w imitates a tube the nearest will be the correct form. The stre of the tube arises from the metal being distributed at the gre distance from the centre, therefore in the section, Fig. 3, the m has been principally distributed in three points AAA of the cir ference of the circle which are connected by the thin sides o iron.

Inasmuch as the vertical strength is required to be conside greater than the lateral strength, this theoretical section, F requires altering to the proportion shown in Fig. 4.

The practical section proposed to be adopted on this prin is shown in Fig. 5, the height is 7 inches and the width 4 in the sides should be as thin as practicable, and the metal thrown the extremities, the sides are therefore $\frac{5}{16}$ inch thick, and extremities $\frac{7}{8}$ inch thick. The weight of this section 13 feet le is 219 lbs., being nearly one-third less than the ordinary oak bar, which weighs 321 lbs.

The following experiments have been tried by the writ ascertain the requisite strength of iron to be employed for purpose.

An English oak sole-bar, 10 feet long, and of the section, F of picked quality and straight grained, was subjected to enc pressure in a hydraulic press, being supported only at the two e

15	tons,	deflected it	⅜	inch at the centre.	
22½	ditto	ditto	½	ditto	ditto.
30	ditto	ditto	⅝	ditto	ditto.
35	ditto	ditto		when it broke.	

aking did not appear to be caused by deflection, but by and lateral separation of the fibres; the principal fraceveral feet in length and extending from side to side vay of the timber.

ht-iron bar, of the Great Western section, shown in he same length, 10 feet, was fixed in the press in the r.

tons, deflection none.

tons deflected it ¼ inch, without set.

„ „ 4 inches, permanent set 2¾ in.

on was entirely lateral, and in the direction of the vards the side of the larger flange.

r is made of two pieces rivetted together, one 7 inches inch thick, with a small flange on one side, and an inches wide, is rivetted to it on the opposite side.

rtain the comparative vertical strength, an English oak 'ig. 5 section, was placed edgeways on two supports, and the force of the press applied in the centre.

10 tons deflected it ⅛ inch.
12 ditto ditto ⅜ ditto.
16 ditto ditto broke it.

ought-iron bar of Fig. 6 section, was tried in the same n the force applied on the edge, and supported on the

ns deflected it ¼ inch.
tto ditto ⅜ ditto, permanent set ⅛ inch.

he results of these experiments it appears that the iron is about as strong as the wood sole-bar, Fig. 1, to resist e, but is somewhat deficient in strength to resist the ing. In this section a loss of strength is caused by its in two pieces rivetted together; the deficiency is in ness, which would be considerably increased if it were l bar of iron. It appears from the following experiment ection would be on the *opposite side* to the large flange, were solid.

½ feet long of the section, Fig. 7, was subjected to ende in the same manner as before; the depth was 6 inches, ½ inches, and thickness ⅜ inch.

s produced no permanent set.

26 tons produced a permanent set of $1\frac{3}{4}$ inch laterally, and
$1\frac{1}{4}$ inch vertically,

the deflection being on the *opposite side* to the flange, as shown by the arrow.

Also a bar, $5\frac{1}{2}$ feet long of the section, Fig. 8, was tried in the same manner by end pressure; the depth and width were both 3 inches, and the thickness $\frac{3}{8}$ inch.

9 tons produced a permanent set of 1 inch, both laterally
and vertically the same,

the deflection being in the *opposite direction* to the flanges, and diagonally as shown by the arrow, from the depth and width being equal.

From these results it appears that the two edges of the bar became compressed by the pressure more than the rest of the section, and allowed the bar to bend outwards. These edges are consequently strengthened in the proposed section, Fig. 9, by increasing the thickness which will diminish the deflection, and enable the bar to resist a greater endway strain without permanent set.

The sectional area of Fig. 6, the bar first experimented upon is $6\frac{1}{2}$ inches, that of Fig. 7 is $5\frac{1}{2}$ inches and that of Fig. 5, the proposed section is 5 inches, but the latter is expected to be stronger than Fig. 6, on account of the greater power to resist deflection, from the edges being strengthened and the bar being made in one solid piece, and that it will prove amply sufficient for the requirements. An important circumstance in the comparison of strength between wrought-iron and wood is, that with iron the full experimental strength is obtained in practice, but in wood the strength obtained in practice is considerably less than that shown by experiment, on account of the defects to which timber is liable and the mortices and bolt holes cut into it.

The writer is about to have a quantity of iron rolled to the proposed Section, Fig. 5, for the purpose of constructing certain waggons, and hopes to be enabled previous to the next meeting to give the results of actual trial.

A very important advantage will be obtained by the use of Iron from its greater durability. English Oak, admitted to be the best material, cannot be procured in a thoroughly seasoned state in any large quantities, and is consequently, after it is made up, in a transition state for a term of years. The timber opens and shrinks, and the joints loosen, admitting wet and accelerating the decay.

at an efficient waggon frame be practicable from to place a limit upon the period of its duration, if m oxidation by paint or tar; and it may be ex- in an efficient condition at the time when wood

noted that the English oak, weighing 72 lbs. per e unseasoned state in which it is generally used that as it seasons in work it lessens considerably he same time loses in strength.

s not had the opportunity at present for carrying on into the application of iron to the construction , further than the principal portions of the under- es to continue the subject practically before the

---

NEYCROFT observed, that he had witnessed some s that were described in Mr. Adams' paper, and e accuracy with which they were performed.

Y suggested it would be difficult to roll a bar of sed section, Fig. 5.

NEYCROFT thought it could be effected, but it anied by some difficulty.

roposed it should be rolled with the ends flat- , and that they should be closed in at the last hrough the rolls.

emarked, that the author's deductions appeared to onclusion that the hollow rectangular section, est form, provided the iron could be rolled into e diverged into the L form because it was the only He thought there would be no difficulty about on, Fig. 2, but there would be some difficulty if it were sufficient for the purpose of fixing the could be rolled out as easily as a tube, and with mandril, might be flattened into any rectangular which would probably be less expensive than ion.

Mr. SELBY apprehended no difficulty in making it i
manner as a tube; at all events he should be glad to ma
trial. He could also prepare it by a process which
prevent the oxidation of the iron, providing it was not k
about.

Mr. COWPER remarked, that the cost of rolling the pr
L section, Fig. 5, might not be more than £2 per ton extr
bar iron.

Mr. ALLAN inquired how the Great Western plan was
to answer, for they had some hundred waggons running
with the frame of the section, Fig. 6.

Mr. BARRANS suggested the adoption of the recta
section, Fig. 2, with wood blocks filled in where require
bolted through to give strength to the frame. He asked
could not be rolled in two parts and rivetted together afterw

Mr. ADAMS replied, that would bring them to an incre
cost per ton, and the expense was an important matter to be
into consideration. It was desirable to get a square side and l
for attaching the spring shoes, with the cross bearers
rivetted through, and he thought a mitre joint at the corn
the frame would be necessary, and that the proposed L se
Fig. 5, was the most convenient for all these purposes.

Mr. WRIGHT said, that in considering the increase in
of Railway Carriages it must be borne in mind that the
had demanded increase of strength and room as essen
comfort and security, more especially in rapid travelling.
thought the comparison between the common road coach an
railway carriage would not hold, because not only did they
a very limited speed, but they were provided by contractors
for the sake of their horses, had the vehicles as light as pos
and it must be remembered there was no danger arising
collisions; there was no buffing, but only traction. The un
requirement of the public had been for an increase of streng
the railway plant, and they had abundant proof that the or
carriages with open frames had not been strong enough to bea
cussion, for in collisions such carriages received all the da
whilst the modern strong built carriages escaped unin
According to the views of the writer of the paper, in increasin

, as a necessary consequence of increased size and
d been going back instead of forward; but he
pinion, on the contrary he thought they were
ng in construction. He could not imagine
bar proposed would be so strong as the
hought good seasoned oak timber would be
for the purpose.

bserved, that the original carriages had not been
ugh for the duties they had to perform, but
t in increasing their strength the dead weight
increased from the want of scientific principles
n.

remarked, that the observations of the paper were
t the best kind of frame, and to discover the
good frame as light as possible, consistent with
bility. He thought that the proposed section,
to give a good result; and he could speak
subject, because he had made a great number of
he end thrust of L and T iron for iron roofs,
that when the edges of the flange were thin, the
in strength to resist an endway thrust. The
from the general centre of the section was
sly placed for strength, and in the section Fig. 5,
stributed as far as possible from the centre,
he full advantages obtained by the depth.

ceived it a matter of the highest importance to
ght, and that great improvements had yet to be
articular; certainly if they had now 5 tons of
e they had formerly 3¼ tons, they had not
for they had thereby increased the cost of
He did not know of any instance where
e a proportion of dead weight in any kind of
e was in railway rolling stock; and the divi-
property must be diminished by it. It was
on a road possessing such perfection and
should have such an enormous proportion of
an abstract sense it rendered the new railways
the old roads, where the proportion of dead
uch less.

Mr. H. Wright thought it ought to be observed, that railway carriages had been much increased in their size, to suit the convenience and comfort of travellers. Originally they were 15 feet long, 6 feet 6 inches wide, and 4 feet 9 inches high; but now they were from 18 to 20 feet in length, 7 feet wide, and 5 feet 6 inches high. The increase in size was of course one element in the increase of weight.

Mr. Clift remarked, that the great increase in speed in the case of railway travelling must be considered, and the necessity for greater strength as a means of preventing accident. At the commencement of the railway system, accidents were frequent; and when they occurred they were of a very serious nature. This was attributed to the lightness of the carriages, and no doubt the question of increasing strength had been forced upon the carriage builders, by the demands of public safety, as well as the danger resulting to the rolling stock, when carriages came into collision. The coal waggons were indeed made as strong as possible, on the principle that if they came in collision with any others, they might from their superior strength, withstand the shock themselves, and crush the others.

Mr. Wright observed, that the increase of weight had been forced upon them on the principle of public safety. Originally, in the case of the axle journals, they were $4\frac{1}{2}$ by $2\frac{3}{16}$ inches; but they had soon increased to 5 by $2\frac{5}{8}$ inches, and were now much larger; also, the wheels were originally 17 cwt., but now they weighed from 25 cwt. to 27 cwt. These had to do the same business; the number of passengers were not increased, but the vehicles to carry them were heavier. It would be found in the case of the old road coaches, that their utmost speed was twelve miles an hour, generally not more than nine miles, and yet accidents were perpetually occurring, and were far greater than at present on railways.

Mr. Gibbons remarked, that the question under discussion, was the substitution of one material for another, of the same strength, not with less strength, but with an economy of weight.

Mr. Slate thought it was important to consider, that the greater the weight, the greater would be the momentum, and

ne damage done by a collision. He saw no e dead weight should not be reduced nearly one-

SON was of opinion, that before long, the dead be reduced one-third, while the weight carried was third: and that the cost would be also diminished. ged in the consideration of the subject, and to bring the results before the Institution, at a .

ks of the meeting were voted to Mr. Adams, for ation; and the following paper, by Mr. Parkinson, as then read:—

ON A WATER METER.

y be considered to be two descriptions of Water ne case with Gas Meters; one in which the meter is pressure arising from the elevated source of the other by the gravity or weight of the water; in other king under pressure and the other not. Perhaps r Meter ever constructed was similar to a steam inder, piston, crank, &c., &c. This description of meter ne pressure, and the water will rise beyond the meter n short of that by which it is moved, save the friction The one moved by the weight or gravity of the allow the water to rise above the point of discharge. ndispensible that this meter should be placed above e the highest supply is required; and if this should est room in a house, the meter must be placed a little course every room below will be easily supplied by the water.

f these plans a variety of designs have been attempted; -pressure principle, besides the cylinder, various having been tried,—and on the plan of gravity various ckets, and vessels with floats, the rising and falling sed the valves, or stop-cocks, for the inlet and outlet

f objections to the high-pressure principle are the making the machines perfectly water-tight, easy to heap construction, to bear the varieties of pressure and

speed to which they may be subjected; another obstacle is the non-elasticity of the water preventing the uniform working, by locking the machine, if the valves or flaps open or shut the least too soon. The chief objection to the meters on the gravity principle is the difficulty of any float opening a valve or stop-cock at the proper times to define the proper measurement of the water.

Looking carefully over all these plans, the writer found none so well adapted as the Gas Meter, which is the one shown in the drawings and model; it is as simple as a grindstone, and turns with the least possible weight of water. The velocity is maintained at a rate as nearly uniform as possible by means of the regulating valve, and will pass the quantities denoted on the badges with a pressure of water varying from 2 feet to 400 feet.

Figure 1, Plate 19, is a front view of the Meter, showing the regulating valve. Figure 2 shows the internal drum, and Figure 1 Plate 20, is a transverse section of the Meter.

A is the inlet valve in the supply pipe which is opened by the ball-cock B, when the water is lowered in the small cistern C, from which the water is supplied for use over the building. D is the regulating valve for maintaining a uniform level of water in the Meter; it is opened by the float E, and is constructed with a piston F upon the valve spindle of the same area as the valve, which balances the pressure on the valve, so that it is not affected by the pressure of the water in the supply pipe, and is easily opened or shut by the float E, however great that pressure may be. The guard plates G check the force of the water passing the valve, preventing the water in the Meter from being agitated.

The drum H is similar to that of a Gas Meter with four compartments, formed by oblique radiating plates which overlap each other nearly half round the drum, and each of the compartments opens into the outer space I of the drum into which the water is poured, and from which the water enters each compartment in succession. The water escapes on the opposite of the drum into the trough K, and in passing through the drum, turns it round, as the oblique position of the divisions removes the outlet opening of each compartment nearly half a revolution from its inlet. The drum revolves freely in the trough K, and the water flows through it with very slight resistance, registering itself by the revolution of the drum as it passes through, and then overflows the side of the trough K and passes into the supply cistern C. The spindle of the

elwork by the worm L, like a gas meter to register gallons on a dial. The trough K is suspended vith an adjusting screw N at the top, by means of aised or lowered so as to adjust the meter accurately as the quantity of water that the drum measures in depends upon the depth of its immersion in the er it is immersed the more water it takes to turn *versa.*

of the Meter should be kept tolerably uniform, as h holds the water will vary a trifle when a large ied into it than a smaller quantity. This is but a low is all round the trough, and therefore the meter re the water correctly when going rather below its when used at full speed gives a trifle over, but less t., in favour of the consumer.

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observed, that he had carefully tested this meter, t measured liquids very accurately, and, indeed, were measured by it more accurately than could ouring from one vessel into another. It was a contrivance, for the valve took off the pressure meter to work with a heavy pressure exactly the mall pressure. Meters had heretofore been made ressure, but it became impracticable to use them rposes, in consequence of their great expense, strength necessary to stand the heavy pressure. placed at the top of the building, and registered assed down to supply the house; the cistern below full, and not more than full, in consequence of which stopped off the supply when the water was He had been informed by Mr. Parkinson, (who tend the present meeting), that he had so many these meters from different Water Works Com- ould not supply them fast enough. The Sanitary had recommended the employment of meteıs for vater to all small houses in large towns, as the were at present supplied at a higher rate than vas probable that some meter would ultimately be Water Companies.

The CHAIRMAN thought it very likely that this plan of measuring water would be very useful, and a meter was much wanted, particularly to those who purchase large quantities of water, as was the case for railway purposes where there was only the imperfect means of measurement into tanks, for ascertaining the quantity consumed.

The thanks of the meeting were voted to Mr. Parkinson for his communication; and the following paper by Mr. R. Peacock, of Manchester, was then read :—

ON THE WORKSHOPS FOR THE LOCOMOTIVE CARRIAGE AND WAGGON DEPARTMENTS OF THE MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY.

These works are erected at the first point from Manchester where the Railway and the land take the same level, viz.: at Gorton, about two miles from Manchester, this being considered the best position from its being near the principal terminus of the Company's Lines, and from the facility with which materials can be procured and workmen engaged; and though it is a terminal establishment, with the advantage of being situated near enough to a First-class Mechanical Town to secure any benefit that may be had therefrom, it is sufficiently far out of it to be clear of the heavy local taxes with which such establishments in all large Towns are burdened.

The site was fixed upon, and land purchased to construct Workshops for the Sheffield and Manchester Railway only; but subsequent to the amalgamation of that Company with the net-work of Lincolnshire lines, and which now form the Manchester, Sheffield, and Lincolnshire Railways, more land was purchased and the Workshops increased in size to meet the wants of the joint Companies. The total quantity of land purchased is nearly Twenty Acres, about Nine of which is occupied by the Workshops and Store-yard, and the remainder is being used for the construction of Reservoirs for supplying the works with water, and for erecting Cottages upon for the workpeople in the Company's service.

The block plan, Plate 21, shows the general arrangement and relative positions of the Shops, Cottages, Reservoirs, &c., the plot of land being bounded on the south by the Railway, on the east by the Peak Forest and Macclesfield Canal (also belonging to this

the north adjacent to the Manchester and Ashton-
road. The Reservoirs are calculated to hold a
tion of water, and are supplied from the adjoining
passing through filter beds in its course from the
servoirs. These Reservoirs from their elevated
the water directly into the Tenders upon the
oughout the Workshops, their position being suf-
lo this, and the Canal high enough to supply the
Cottages shown on the plan are 140 in number,
locks; and between the Cottages and Reservoirs,
ps, is a plot of vacant land that may be used for
umber of Cottages, or for any other purpose that
required.

the works is nearly that of a square, the Watch-
being situated towards the Cottages on the east
s, as also is the rail entrance, and adjoining are
eneral Stores.

-house or shed for working Engines, Plate 22, is a
feet in diameter inside, and will hold seventeen
eir Tenders, leaving the entrance and exit lines
antage in this description of building over the
is in the absence of pillars for supporting the roof,
one in the rotunda, while in the polygon, say of
re would be twelve, and the number of pillars
the number of lines and consequently the
nes it will hold, while in the rotunda the number
the number of Engines, influenced only by the
d for each other; thus, the polygon would hold
ith the entrance clear, while the rotunda will hold

of the entrance is a furnace for lighting up the
d the points for the two lines to the table are set
nes will (on entering) go upon the right hand side
d thus, supposing them to enter Engine first, they
nto each line, which will cause the smoke box, or
he Engines, to be always nearest the table, and
a right position for the tubes &c. being cleaned.
in the centre is 40 feet diameter, with two lines of
upon each side the Centre Pillar around which it
tre pillar is of cast iron, the base forming the bed

for the inner rollers of the turntable to revolve upon; the top of the pillar is sufficiently large to receive the shoes for carrying the principals of the roof, and to which they are secured by bolts, each principal radiating from the centre of the pillar, and its opposite end resting upon the outer wall of the building. A collar is cast upon the pillar about 8 feet from the top, which was intended to carry one end of a circular travelling frame; the frame being intended to revolve round the pillar, and the opposite end having a carriage running upon a circular rail beam, which was to have been supported by the pilasters built on the inside of the walls, the frame being surmounted by a travelling crane in the usual way; this however has not yet been carried out. The roof is of wrought iron, surmounted by a louvre, the top of which is glazed; the whole forming a beautifully ventilated and well-lighted building.

To the left of the rotunda are the workshops, with Engine-house, boiler, &c. The Fitting and Tool Shop is 120 feet by 60 feet, and contains the whole of the Tools, with the exception of the Punching and Shearing Machines. Two rows of Fitter's Benches are erected near the far end; the Lathes, Drills, &c., are placed down each side, and have their counter shafts carried by wall plates, built into the side walls, and the Planing Machines are placed in the centre, the whole being driven from two lines of Main Shafting passing longitudinally down the shop, one over the vertical shaft from the Engine, and the other equidistant from the opposite wall, this shaft being continued over the Shop Stores and passing over the Travelling Platform into the Carriage Shed for driving the Hoist therein. The Smith's Shop is next to the Fitting Shop, and is of the same dimensions, 120 feet by 60 feet; it contains a Fan and sixteen Smiths' Fires, eight of which are placed upon each side of the Shop, and if necessary three more can be placed at the ends. Next to this is the Boiler Shop, the same size as the Smithy, in which are erected eight smiths' fires, on the side next to the Smiths' Shop; four boiler fires are placed upon the opposite side, and the punching and shearing machines at the entrance end, these and the fan being driven by a shaft passing from the Engine transversly across the ends of the shops. Adjoining to the left and at right angles with these is the Erecting Shop, which is 150 feet by 60 feet, in this are nine transverse lines of rails, each line holding two engines, down each side and the centre are pillars supporting longitudinal beams for carrying the Travelling Cranes one

; both these Cranes traverse the full length of the each calculated to lift an Engine and move it to any p, if necessary.

t, and bounding the west side of the works, are the arriage Shops, the Waggons being on the ground-floor ges above; the carriages are lifted up and down by vorm-hoist, worked by the shop Engine. These feet by 70 feet, the Carriage shop will hold thirty-, and the ground-floor about fifty waggons; at the re the lifting-room below, and the Trimming and above, each 60 feet by 70 feet. The lines in the gon shops are served in common with the erecting lling platform, 20 feet by 12 feet, running upon three ngles with the lines in the shops.

e lifting-shop, and forming part of the south boundary, 60 feet by 40 feet, and in continuation of this is a king stock not required for present use; this eet by 40 feet, and may be used for working essary. In a line with this and at the south he works is the Coke Shed, 100 feet by 40 feet; this is that the Coke Waggons are on one side and the other, the Coke being filled into baskets upon a plat-e Engines and Waggons, and transferred from thence the waggon line side of the shed is closed, as also the ngine line inside of the shed is open, the roof merely the Engines, where they are being coked.

gement of the lines into and in the works, with the nning parallel with the railway outside, is shewn by Plate 21.

COCK observed, they had never experienced the lty with the turn-table in the rotunda, or the two e two years that they had been at work. There arising from a want of balance on the turn-table line was loaded with an engine, because each line ried by an independent pair of girders, supported joined together in the centre. They could turn an he table in about a minute, with three men,

and it was sometimes done by two cleaners. The object in the arrangement had been to get as many engines in as small a space as possible, and they could find no other shape so well adapted for the purpose, or into which so many engines could be got in proportion to the area, with the same convenience and room for getting about them. The total area of the floor of the building is a little over 17,000 square feet, which is equal to 1,000 square feet of shed surface per Engine accommodated, with ample room to get conveniently around each, and leaving the entrance and lines clear.

Mr. DOCKRAY did not see what was gained by the oblique arrangement. At Camden-town the rotunda was 160 feet in diameter, and held 24 engines on the old arrangement, the space allowed for an engine and tender being 50 feet in the centre to turn. If the columns in that arrangement were placed sufficiently far back to get a clearance between the engines, he considered they would not lose any space.

Mr. PEACOCK observed, that although the columns might be put so far back as to clear the lines, columns were always very objectionable and inconvenient at the side of the engines, and he thought the central column much preferable.

Mr. COWPER suggested, that with a roof of only 150 feet span, the columns might be entirely done away with, and the cost not be increased more than £1 per square.

Mr. PEACOCK observed, with respect to lifting the carriages into the upper shop, that it was effected in two minutes by the worm hoist; the time was not an object of importance, as there were only about two carriages raised per day.

Mr. GIBBONS suggested, that the air-lift might be very advantageously employed for the purpose. By a very small abstraction of power continuously going on they would procure a reservoir of power of large amount ready to be applied when requisite, and be enabled to lift the carriages in a quarter of a minute. There was one advantage in the employment of compressed air, that it was more under command than any other power and more easily regulated.

Mr. PEACOCK did not think that plan could be applied economically in the present case, as it would involve the expense

voir; the object had been to get something to se as simple and cheap as possible, and the only yed was a 1-foot worm working into a 4-feet

MAN proposed a vote of thanks to Mr. Peacock, l; and the following paper, by Mr. F. Bramwell, hen read:—

VED VACUUM GAUGE FOR CONDENSING

late 20, represents the ordinary Long Vacuum mercury is contained in an uncovered cast-iron immersed a glass tube, open at the bottom end, top. A small iron pipe, with a stop-cock and con- ndenser, passes through the mercury, and up the to the top. By this pipe the air is exhausted from nd the mercury rises in it in proportion to the n the pressure of the atmosphere, and of the pour in the condenser. The objections e, firstly—that it does not indicate the real ncondensed vapour remaining in the Condenser, n opportunity of comparing it with a barometer; hat the mercury is frequently drivenout and lost, being left open, while blowing through previous to Gauges are also of necessity cumbrous, as they feet long, to shew the higher vacuums of 29 and

Plate 20, represents the Ordinary Short Vacuum mall glass tube closed at the top contains the mer- ottom is bent upwards, ending in a bulb which has its upper side. This tube is carefully filled in the the ordinary barometer, and is then attached to a losed in a glass case, which is cemented to a brass in a stop-cock and a pipe, by which the connection Condenser, so that the air in the interior of this case ame density as that in the Condenser; and as the s only from 8 to 10 inches long, it is evident that be held up in it by the pressure of the air in the the density of it is reduced below that, which is a column equivalent to the height of the tube.

By this means, when it is required to shew only the higher d
of rarefaction, as in steam engines, the gauges may be
extremely short and compact, and it is evident that they will
indicate the total pressure of the uncondensed vapour, irres
of the state of the atmosphere. For these reasons this gau
been very extensively used, and no doubt its emplo
would have been universal, had it not been for two objections
first and gravest being, that the vapour from the Condenser d
frequently on the inside of the glass case and forms a mi
so dense a one, as not only to render it impossible to
the height at which the mercury is standing, but to see e
scale itself. The second objection is, that if the stop-cock
shut off previous to blowing through, the inside of the glass b
filled with steam or hot water, and is very liable to be
thereby. The joint between the glass case and the bra
generally leaks, and this to such an extent that the gauge is
always shut off, to prevent the vacuum being injured by the
of air into the condenser.

Figure 4, Plate 20, represents the Improved Short V
Gauge. The principle is precisely similar to that of Figur
difference being merely in the arrangement. Instead of imr
the whole of the tube and scale in a glass chamber connect
the condenser, the bulb only is enclosed in a brass cup, with
lid (on which the scale is cast), and the rest of the mercuri
is passed through a stuffing box in the middle of this lid, pro
it from injury by sinking it in a depression in the scale
common thermometer. On the bottom of the brass cup is th
cock with the pipe, by which connection is made with the con
the same density is always preserved in it and the cup ; an
the pressure being removed from the surface of the mercury
bulb, it of course falls according to the rarefaction ; a fa
can be always observed, as the tube containing the mer
totally uncovered. By this means the first and great obje
the short vacuum gauge is done away, and likewise the
which is common to both long and short, viz.—the risk of th
cock being left open while blowing through ; as with this gau
a matter of perfect indifference whether it is open or not, as t
thing that takes place if it is open, is that the brass closed cup
with steam, but this can neither blow out the mercury nor
the gauge. In fact, those that the author has at work un

ever shut off. As regards their leakage, he has
y pains to get them as tight as possible; and in
succeeded that the first one put to work, nearly two
e of the pumping engines, at the Grand Junction
Brentford, retained the mercury at 29 inches, for a
engine stopped, and no doubt would have
present day, had it not been opened. The
ade with a hollow plug; this is done for
so to diminish the risk of leakage, as one end
his arrangement contained in the pipe leading
This could not conveniently be done with any
ere are none, it is believed, sufficiently light and
rried by one point of support only, and that the
he author first had these gauges made in January,
en about thirty or forty of them have been adopted,
od are all giving satisfaction.

method of arranging the short vacuum gauge
bvious a one, that the author is quite prepared to
ot a novelty to some of the members, although
himself. It may be observed, as an apology for
a simple matter, that the alteration in the arrange-
t is, has produced a neat and cheap instrument,
ectly, in place of a rather unsightly and expensive
quently utterly useless from its being obscured
sing in it.

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r observed, that the instrument was very efficient
ntended. He could speak practically on this
not new to him, although he was not before aware
Mr. Bramwell's invention. For three years he had
same construction in use at Fox, Henderson,
They worked extremely well, and there was no
ting off the cock; he believed it was the idea of
Birmingham, by whom those instruments were

MAN thought that the instrument, though a simple
rtainly a valuable improvement.

s remarked, it was interesting to find different
plied to the same practical subject, arriving
t.

The thanks of the meeting were voted to Mr. Bramwell, for his communication; and the following paper by Mr. Barrans, of London, was then read:—

ON AN IMPROVED AXLE BOX FOR RAILWAY ENGINES AND CARRIAGES.

The attention of the writer was first drawn to the present subject by the wearing of the Axle Bearings at their ends, and the great number of brasses that were in consequence thrown aside as useless before being half-worn through, the expense of repairing such as were retained for work, and the loss of time, as well as expense, incurred by the necessity of lifting both Engines and Carriages for the purpose of either renewing or repairing, and replacing the bearings so worn; and in the consideration of this subject it becomes evident that some portion of the accidents and a large amount of expense are to be attributed to this great source of mischief.

The Engines and Carriages in the early part of their work, whilst the journals and wheels as well as the road are true, run steadily without deviating from the line of their course, whether straight or curved; but the friction of the shoulder and collar of the journals against either end of the bearings causes wear upon the latter which increases in proportion with the amount of wear. A new motion endways of the Axle takes place, which, aided by the superincumbent weight, causes the shoulders and collars to strike as well as revolve, and to beat up the metal, which is then peeled or turned off by the subsequent revolution of the shoulder or collar against the bearing; hence a twofold cause of destruction is created and actively in progress, the rate accelerating with the progress. This work of destruction goes on until to avoid danger to the passengers or rolling stock, or complaints of discomfort, it becomes necessary to put a stop to it either by fitting in new bearings, or by turning up, or otherwise repairing the old ones. The turning up of the wheels of both Engines and Carriages is a work of frequent occurrence, occasioned by the rubbing or grinding of the tire, and striking of the flanges of the wheels against the rails, which observation and experience have proved to originate in the endway motion of the axles. That the expense incurred in rectifying this mischief forms a not unimportant item in railway expenditure, and the loss of time occasioned by it a

lerable delay, is well known. Also the excess of being once commenced, its effects are ere long erangement of the Permanent Way; and, as soon as Way becomes out of order, its very derangement in a cause of mischief, and combines in the general ad destruction of both way and machinery.

il of the endway motion in axles is the oscillation e Engines and Carriages, which contributes by g and vibratory motion to the excess of wear, and f all the joints of their machinery, and adds to the low with which the flanges of the wheels strike s, creating undue straining upon the guide plates, their fracture and excessive wear. This also adds of breakage of the axles by the lateral strain from the vheels suddenly striking the switches and crossings ough them, as well as the main rails; the effect of iking or blow being so much greater, and of so much s tendency, when it is aided by the weight of the oad, and risking not only the probability of the fracture t also of the vehicle when at high velocity getting This oscillation also occasions much discomfort to d ground of complaint. Every time the flange of kes against the rail, the speed of the vehicle is he progress of the train retarded, unless the check vercome by the exertion of a greater amount of er than would otherwise be required; hence a neces- greater consumption of fuel, and a consequent nse is occasioned: and it may be remarked also, king of the Engine arising from the endway motion and the concussions of the flanges of the wheels s, much of the firing is from time to time shaken box, and wasted on the road, thereby adding to the f fuel.

te 23, shews a section of the Improved Axle Box. *ring-piece*, fitted to slide in the boss L, and capable ed to any required distance from the end of the axle w the latter to revolve without friction, and at the enting any excess of endway motion. The end of little rounded, and is lubricated through the hole bove it; the bearing-piece acts *eccentrically* against

the end of the axle when in contact with it, for the purpose of ensuring its constant lubrication. The adjustment is effected by the hand pushing up the bearing-piece to the end of the axle, and then withdrawing it a short distance, so as to leave merely a slight working clearance between the two; it is then fixed in its place by the point of the set-screw E entering one of the holes F, which are arranged in a spiral form round the bearing-piece, so as to allow of its being adjusted to 1-32nd inch; the set-screw is kept in its position by a jam-nut.

Fig. 2 shews a method of applying the principle to existing axle boxes of railway stock, by bolting the boss L on to the front of the axle box.

Figs. 3, 4, and 5, shew various modifications of the same principle. In Fig. 3, the end bearing-piece B is adjusted by means of the screw-socket C, which is fixed by a jam-nut and set-screw; in this case the end collar of the axle journal is dispensed with. In Fig. 4 the adjustment is effected by the wedge D; and in Fig. 5 the end bearing-piece B is made in the form of a wedge and slides between two guide-pieces, being pressed up by a screw. Several other modifications are employed to facilitate the application of the principle to the various patterns of axle boxes, either new or old.

The modification shewn in Fig. 3 is, (with the exception of the Grit shield) that in which the improved Boxes were first applied upon the leading and trailing wheels of the Brighton Express Engine, which has worked with them upwards of 10,000 miles; and also upon a Carriage on the South Eastern Railway, where the bearings were purposely made half an inch too short, to resemble worn bearings, by which means in a journey from London to Dover and back, the fact of its oscillation was first manifested, and in the course of the return to London, during a short stoppage at Ashford of the train in which it ran, the end bearing-pieces were adjusted, and the oscillation consequently ceased; one of the axle boxes from this carriage is laid before the Meeting. The Engines to which the improved Boxes have been applied, have become in consequence so much steadier in running, that the full speed can be safely maintained over bad parts of the road, where before it was necessary to slacken speed. An important advantage is the facility with which the adjustment can be effected whenever required, without taking the engine or carriage out of the train.

int is the Grit and Dust that is thrown up by the wind, finding their way between the journals and the injury done by this cause is manifest in the axles and bearings, with their concurrent excessive wear, and the delays and expense attendant upon l to remove this, the Grit Shield is designed in the ox. The circular ring S is attached by two screws of the axle box, and the corresponding ring T is axle and revolves with it; the flanges of these with each other without touching or causing any ent any grit or dust from passing between them e journal. The grit shield is not applicable to e present form of their wheels and axles.

of the remaining portion of the invention is to of the lubricating material used for the journal ccurs in the ordinary axle boxes, and to save the d for this purpose and work it over and over again, reducing one important item in the working nder cap is slipped up into the lower part of the d fixed there by bolts passing through the sides; hich in new axle boxes is cast in one with the box) acle for the cast-iron Grease Drawer H, which r part of the axle box and is secured by the spring ibricating material passing over the journals, falls and may whenever necessary, by turning over the rawer into the top of the box, be used again and ıbricating properties have become deteriorated; it gently in a vessel with a small quantity of water, atter will sink to the bottom, and the grease and t the top, purified and again fit for the purpose of this means the large amount of saving has resulted n 5-6ths to 7-8ths of the tallow and oil passed over material proving afterwards even of a better lubri- an at first, from the ingredients becoming more

ther material advantage attending this part of the uch as Oil, which is generally admitted to be a and more certain in its action than grease of any ostly kept out of use, by reason of the great waste

attending it in ordinary axle boxes, and its being inapplicable in others; but in these improved boxes, the whole material being caught in the grease drawer, and again returned into the box, oil may be applied with great economy and advantage, always being ready and keeping up its gradual and constant supply; whereas with grease of any kind the axle must have become heated sufficiently to melt the grease before the latter can come into operation; and thus a serious mischief will have commenced, which by very small increase will, and does in practice, rapidly melt and allow to run away the only means by which the heat can be kept in subjection, and frequently gives rise to lifting and repair and throwing the vehicle out of work. Also in these improved boxes, by merely taking out the grease drawer, a convenient means is at once afforded of examining the state of the journals and boxes, which, with the ordinary boxes, it would require lifting to accomplish.

Mr. Barrans exhibited specimens and models of the improved axle boxes, and specimens of the grease that had been used once and three times respectively; also certificates of the saving in tallow and oil, amounting to 3-4ths, and 7-8ths, that had been ascertained in a trial with these axle boxes on an Engine on the Brighton Railway, and a Carriage on the South Eastern Railway.

Mr. Adams remarked, that he had found that waggons and carriages did not work well unless there was plenty of end-play in the bearings; for if fitted up very close they were liable to heat. In the case of waggon bearings, he thought a play of 3-16ths of an inch was requisite.

Mr. Wright was of opinion that the more play was left in the bearings the more would be the wear; he thought 1-16th inch was abundant.

Mr. Henson observed, that he did not leave any end-play in waggon bearings; on the contrary, so accurately were they adjusted, that red lead, or something of the kind, was employed to ascertain the complete fit; in fact, they too soon acquired the play in the course of work. The only thing of importance was

h reference to that they had scarcely any trouble, f 2,500 waggons they very rarely had cases of hot used a very large grease chamber, and hence, vas a large quantity of grease present, the bearing l that there was very little demand for it.

discussion of the subject was adjourned to the d a vote of thanks was passed to Mr. Barrans

g then terminated; and in the evening a number and their friends dined together.

SUBJECTS FOR PAPERS.

Steam Engine Boilers, particulars of construction—form—heating surface—cost—consumption of fuel—evaporation of water—pressure of steam—steam gauges, high pressure and low pressure—explosion of boilers and means of prevention—effects of heat on the metal of boilers, low pressure and high pressure—incrustation of boilers and means of prevention—evaporative power and economy of different kinds of fuel, coal, wood, charcoal, peat, patent coal, and coke—smoke consuming apparatus, best plan and results of working.

Steam, expansive force and best means of using it—power obtained by various plans—comparison of double and single cylinder engines—indicator figures from engines, with details of useful effects, consumption of fuel, &c.—contributions of indicator figures for a general book of reference to be kept in the Institution.

Pumping Engines, particulars of various constructions—size of cylinder, strokes per minute, and horse power—number and size of pumps and strokes per minute—application of pumps—fen draining engines

Blast Engines, best kind of engine—size of cylinder, strokes per minute, and horse-power—number of boilers—size of blowing cylinder and strokes per minute—means of regulating the blast—improvements in blast cylinders.

Marine Engines, power of engines in proportion to tonnage—different constructions of engines—comparative economy and durability of different boilers, tubular boilers, &c.—weight of machinery and boilers,—kind of paddle wheels—speed obtained in British war steamers, in British merchant steamers, and in Foreign ditto, with particulars of the construction of engines with paddle wheels, &c.—screw propellers, particulars of different kinds, number of arms, material, means for unshipping, horse-power applied, speed obtained, section of vessel.

Rotary Engines, particulars of construction and practical application—details of the results of working.

Locomotive Engines, express, passenger, and luggage engines—general particulars of construction, details of experiments, and results of working—speed of engines, cost, power, weight, steadiness—consumption of fuel—heating surface, length and diameter of tubes—experiments on size of tubes and blast pipe—comparative expense of working and repairing—best make of pistons, valve gear, &c.

Engines worked by Gas, Gun-cotton, or other explosive compounds.

Electro Magnetic Engines, particulars and results.

Water Wheels, particulars of construction and dimensions—form and depth of buckets—head of water, velocity, per centage of

obtained—scoop wheels for draining—turbines, construc-
and practical application, power obtained, comparative
and economy.

LS, particulars of construction—number of sails, surface
form of sails—velocity, and power obtained—average
er of day's work per annum.

LS, particulars of improvements—power employed—appli-
of steam power—results of working with an air blast—
tages of regularity of motion.

LS, particulars of the construction and working—results
application of the hydraulic press in place of rolls.

S, particulars of construction—mode of driving—power
yed—particulars of work done—best speeds for vertical
ircular saws—form of saw teeth—saw mills for cutting
imbers.

, facts relating to the construction and working.

LLS, information respecting the construction and arrange-
of the machinery—power employed, and application of
—cotton presses, mode of construction and working,
employed.

for manufacturing Flax, both in the natural length of
and when cut.

ILLS, improvements in machinery for making iron and
-mode of applying power—steam hammers—piling of
plates—fancy sections.

ND COINING MACHINERY, particulars of improvements, &c.

KING AND PAPER CUTTING MACHINES, ditto ditto.

IACHINES, ditto ditto.

INTING MACHINERY, ditto ditto.

MPS, facts relating to the best construction, means of
ng, and application—best forms—velocity of piston.

ditto ditto ditto.

PRESSES, facts relating to the best construction, means
rking, and application.

IES, ditto ditto ditto.

ditto ditto ditto.

ditto ditto ditto.

NES, ditto ditto ditto.

AISING TRUCKS, &c. ditto ditto ditto.

LANING, BORING, AND SLOTTING MACHINES, &c., particulars
provements—description of new self-acting tools.

WHEELS, best construction and form of teeth—results of
ng.

ELTS AND STRAPS, best make and material, leather, rope,
percha, &c.—comparative durability and results of
ng—power communicated by certain sizes.

OF MATERIALS—facts relating to experiments on ditto,
eneral details of the proof of girders, &c.—girders of cast

and wrought-iron, particulars of different constructions, and experiments on them—best forms and proportions of girders—best mixtures of metal.

DURABILITY OF TIMBER of various kinds—best plans for seasoning timber and cordage—results of Kyan's, Payne's, and Burnett's process—comparative durability of timber in different situations.

CORROSION OF METALS by salt and fresh water, and by the atmosphere, &c.—facts relating to corrosion, and best means of prevention.

ALLOYS OF METALS—facts relating to different alloys.

FRICTION OF VARIOUS BODIES—facts relating to friction under ordinary circumstances—friction of iron, brass, copper, tin, wood, &c.—proportion of weight to rubbing surface—best forms of journals, &c.—lubrication, best materials and means of application, and results of practical trials—best plans for oil tests.

IRON ROOFS, particulars of construction for different purposes—durability in various climates and situations—comparative cost, weight, and durability—roofs for slips of cast-iron, wrought-iron, timber, &c., best construction, form, and material.

FIRE-PROOF BUILDINGS, particulars of construction—most efficient plan—results of trials.

CHIMNEY STACKS of large size, particulars, mode of building, &c.

BRICKS, manufacture and durability—fire-bricks and fire-clay.

GAS WORKS—best form, size, and material for retorts—construction of retort ovens—quantity and quality of gas from different coals—improvements in purifiers, condensers, and gas holders—wet and dry gas meters—pressure of gas, gas exhauster—gas pipes, strength and durability, and construction of joints—proportionate diameter and length of gas mains, and velocity of the passage of gas—experiments on ditto, and on the friction of gas in mains and loss of pressure.

WATER WORKS—facts relating to water works—application of power, and economy of working—proportionate diameter and length of pipes—experiments on the discharge of water from pipes, and friction through pipes—strength and durability of pipes, and construction of joints.

WELL SINKING and ARTESIAN WELLS, facts relating to.

COFFER DAMS and PILING, facts relating to the construction.

PIERS fixed and floating, and Pontoons, ditto ditto.

PILE DRIVING APPARATUS, particulars of improvements—use of steam power—facts relating to Pott's apparatus.

DREDGING MACHINES, particulars of improvements—application of dredging machines—power required, and work done.

DIVING BELLS, facts relating to the best construction.

CAST-IRON LIGHTHOUSES, ditto ditto.

MINING OPERATIONS, facts relating to mining—means of ventilating mines, use of steam jet and ventilating machinery—mode of

aterials—mode of breaking, pulverizing, and sifting
escriptions of ores.
s relating to blasting under water, and blasting
—use of gun cotton, &c.—effects produced by large
charges of powder.
ES—consumption of fuel in different kinds—burden,
d quality of metal—pressure of blast—horse power
-economy of working—improvements in manufacture
comparative results of hot and cold blast.
ACES, best construction—consumption of fuel, &c.
ES, best construction—size and material—power of

and FANS generally, with facts relating to the amount
employed, and the effect produced.
RCOAL, particulars of the best mode of making.
nstruction of permanent way—section of rails, and
manufacture—experiments on rails, deflection, dete-
and comparative durability—material and form of
size, and distances—improvements in chairs, keys,
fastenings.
CROSSINGS, particulars of improvements, and results
g.
articulars of various constructions and improvements.
ations and Trains, and self-acting signals.
rriages and Waggons, best construction.
arriages, &c., and Station Buffers—different construc-
materials.
rriages, &c , buffing and bearing springs—particulars
t constructions, and results of working.
ELS, wrought-iron, cast-iron, and wood—particulars
t constructions, and results of working—comparative
nd durability—wrought-iron and steel tires, compara-
my and results of working.
ES, best description, form, material, and mode of
ure.

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ncil invite communications from the Members and
on the preceding subjects, and on any Engineering
will be useful and interesting to the Institution; also
of Engineering drawings, models, and books for the
Institution.

munications should be written on foolscap paper, on
of each page, leaving a clear margin on the left side
they should be written in the third person. The
trating the communications should be on so large a
clearly visible to the meeting at the time of reading
ation, or enlarged diagrams should be sent for the
any particular portions.

INSTITUTION OF MECHANICAL ENGINEERS.

BALANCE SHEET,

For the year ending 31st December, 1850.

Dr.	£	s.	d.
To Subscriptions from 16 old Members, being Arrears for 1849	48	0	0
„ ditto from 150 old Members for 1850	450	0	0
„ ditto from 13 new Members for 1850	65	0	0
„ ditto from 3 new Graduates for 1850	9	0	0
„ ditto in advance for 1851	3	0	0
„ Donation from R. Stephenson, Esq., M.P.	100	0	0
„ Sale of Extra Reports	1	6	0
„ Balance from 31st December, 1849	195	11	3
	£871	17	3

Cr.	£	s.	d
By Stationery, Printing, and Engraving	76	6	0
„ Alterations of Building for Meeting Room, and Offices and Gas-fittings	71	11	6
„ Furniture for ditto	32	1	5
„ Office Expenses and Petty Disbursements	26	5	9
„ Travelling Expenses	2	11	9
„ Reporting	12	9	0
„ Parcels	7	7	10
„ Postages	22	1	6
„ Salary	300	0	0
„ Rent and Taxes	90	19	6
„ Balance	230	3	0
	£871	17	3

(Signed) J. E. CLIFT.
WM. BUCKLE.
ARCHIBALD SLATE.

15*th January*, 1851.

INSTITUTION

OF

ANICAL ENGINEERS.

REPORT OF THE

ROCEEDINGS

AT THE

GENERAL MEETING,

BIRMINGHAM, ON 23RD APRIL, 1851.

McCONNELL, ESQ., VICE-PRESIDENT,

IN THE CHAIR.

BIRMINGHAM:
TED AT M. BILLING'S STEAM PRESS OFFICES,
74, 75, & 76, NEWHALL STREET.
1851.

PROCEEDINGS.

RAL MEETING of the Members was held at the
nstitution, Newhall Street, Birmingham, on Wed-
pril, 1851, J. E. McCONNELL, Esq., Vice-Presi-
r, in the unavoidable absence of the President.

of the last General Meeting were read by the
onfirmed.

AN announced that the Institution had been pre-
Peter Hollins, of Birmingham, with a copy of the
been executed by him of the great engineer,

g supplementary paper by Mr. Joseph Barrans, of
n read :—

VED AXLE BOX FOR RAILWAY ENGINES AND CARRIAGES.

on and object of the improved Axle Box are explained
per, read at the last meeting of the Institution ; (see
ings, January 22nd, 1851, and Engravings, Plate 23 ;)
consisting of an End Bearing-piece, of different con-
the various circumstances of engines and carriages,
nearly to touch the end of the axle, and to prevent
rnal ; also a Grit-shield, to prevent grit or dust getting
and a Grease drawer, to catch the lubricating material
ournal, and enable it to be used over again with

of the Axle Box for Carriages has since been con-
l instead of grease, as it is a better lubricating mate-
tain and regular in its action ; the oil being always
ng up a gradual and constant supply, but the grease
to be partially heated before it is melted, and can flow

on to the journal; the Grease-drawer prevents the waste that would attend the application of oil in ordinary axle boxes. The cover of the box is made with a lip all round the edge, which shuts over the projecting edges of the opening, so as to prevent any of the water used in washing the carriages or otherwise from getting into the box, as the oil being lighter than the water, would otherwise be lost out of the box if the water were allowed to get in.

These boxes have been applied to a Carriage on the South Eastern Line, where it has been working, lubricated with oil only, for the last three months, perfectly cool and steady, and having neither required nor had any attention to the lubrication on any journey between London and Dover, between which places it has run alternately in the Mail and express Trains; and in an accurate experiment, tried for the continuance of a week, during which it ran 1092 miles, it was found that rather less than half a pint of oil had been consumed in lubricating the four boxes. The Dover Mail Engine, with these boxes applied to the leading wheels only, has been working for the last five months lubricated with oil only, and running cool and steady; these boxes have also been working on three Engines on the Brighton Railway, one of which has run with them 14,260 miles, (these Engines being lubricated with oil and grease,) producing great steadinesss of running, and giving perfect satisfaction, which they continue to do to the present time. An experiment on one of these Engines showed that in one week, during which it ran 1004 miles, out of three pounds of tallow and two pints of oil, delivered out of store for lubricating the two leading boxes of that Engine, 3 lbs. 6 oz. of mixed oil and tallow was caught in the grease-drawer, and returned into store, besides a pound of tallow and oil left in the tops of the boxes, thus showing a saving of seven-eighths of the total quantity. These boxes have also since been applied to a first-class Carriage, and to a Break-carriage of the Brighton Express Train, lubricated only with oil, with the old worn bearings continued in the boxes, and in a week's daily running from Brighton to London and back, half a pint of oil only having been supplied to each box; less than one half the quantity so supplied was consumed, and these carriages ran perfectly steady and cool.

ᴵs exhibited a specimen of the axle-box arranged to and stated that, by the plan adopted, they found ving was effected in the cost of the lubricating in the trouble and attention required for the

ʀ inquired whether, as the brasses wore, and the was screwed up to follow the wear, there would cement of the axle-box, and a strain thrown on and the spring-ties?

ɴs said that there would not be any displacement , as the effect of the adjustment was simply to ays in the same correct position that it had when d to prevent lateral movement taking place when worn shorter. He did not allow the adjusting so as to occasion friction, and there was a slight s left at the ends of the axle.

observed that, when the ends of the brasses were s of the journals would be useless.

ɴs replied, that no collars were required on the is axle-box; and he proposed in new axles to make ite plain without collars, as shown in one of the Fig. 3, Plate 23.)

ᴍᴀɴ inquired whether they had had any particular the steadiness of the carriages where this axle-box the other similar carriages where it was not used?

ɴs replied, that in the engines where the box was ning was unusually steady; the engine-drivers were se the speed in consequence in passing over the worst parts of the line; and the guards reported ages ran much steadier than before that are fitted oved axle-boxes. He had endeavoured to try a

more accurate comparison by the oscillation of a pendulum across the carriages, but could not succeed in obtaining a result.

The CHAIRMAN said some more definite comparison than the opinions of the men was required, as there were many circumstances to render them erroneous on such a question.

Mr. ADAMS thought they would still have some end-play, from the springing of the axle-guards, or play in the hanging of the springs, although the play was stopped in the bearings.

Mr. BARRANS replied, that the end-play given by the ordinary clearance between the flanges of the wheel and the rails was quite sufficient, without having end-play in two places, which would be of no use; and he thought it was much better to have the end-play only in one place at the flanges of the wheels, where it was unavoidable. He had only one-sixteenth of an inch play in the axle-guards.

Mr. ADAMS said he always sent out carriages with the brasses closely fitted to the journals; but, after a time, they always got end-play, by the wearing away of the metal. He eased the end blow by having a differently formed shoulder to that adopted by Mr. Barrans; instead of a square shoulder, which injured and abraded the metal with the end blows, the shoulders were well rounded with an easy hollow, so as to make the brasses wear longer, and ease the force of the end blows; but with Mr. Barrans' centre pin there would be a sudden end blow.

Mr. SLATE showed, by one of the specimens of brasses exhibited, that the shoulders of the journal were liable to wear into the ends of the brasses.

Mr. HENSON said he had break-waggons at work that had travelled 15,000 to 25,000 miles without the brasses being changed; and at the conclusion of that period some of the brasses were so little worn as to be put in again. These waggons ran so steadily that a small print could be read in them; he objected to any end-play, and considered that he effected the same result as Mr. Barrans without any complication or expense, by making the brasses always a good fit at starting.

Mr. BARRANS showed that, when brasses were worn too much

would be stopped at once by the adjusting piece,
ng the brasses or lifting the waggon ; the clearance
t the ends of the axle that there could not be any

ON thought that Mr. Barrans' plan would increase
the axles, and produce complication.

M said, checking the end play enabled an engine
ithout slackening speed over the bad parts of the
nen who had driven engines, in which Mr. Barrans'
in use, stated that they went over the bad parts and
out checking speed, which they could not do before
applied.

MAN remarked, that such evidence was, of course,
and to be received with caution, as the opinions
ned without sufficient data.

ON thought the saving in the brasses would not be
nse of applying the apparatus to every axle-box,
e very considerable in a stock of 2500 waggons on
0,000 axle boxes.

ER said, the real question was in the comparative
ting the waggons and changing the worn brasses
too much play, or of merely screwing up the
ilst the waggon was still kept at work.

MAN observed, that the object of Mr. Barrans' plan
he axles of engines and carriages from getting end-
rnals and swerving sideways, as in a certain time'
night be taken in the original make, the brasses
nd injurious end-play would take place. If they
carriage steady on the axle, prevent that oscilla-
re or less generally occurred, and keep the axle
s right, instead of gradually wearing away and
they would accomplish a great benefit for the
s, and the comfort and safety of the public ; and if
nvention prevented the necessity of taking out and

changing the brasses for that purpose, it appeared to be advantageous. It might be, perhaps, that they were not changed soon enough now, on account of the trouble and expense; and it appeared better to keep them always in right adjustment than to allow them to get gradually wrong. He thought Mr. Barrans had taken much pains with the subject, and that the Institution was indebted to him for bringing it before them; some further improvements might perhaps arise in the invention, or some other means be proposed for accomplishing the object.

Mr. Adams suggested the consideration of such a form and depth of shoulder to the journal, as at the end of a series of years, would be in the same position as at the commencement, and that would wear equally at the shoulders and in the middle of the bearing, so as to keep them always in the same adjustment of play as at first.

A vote of thanks was then passed to Mr. Barrans for his communication; and the following paper, by Mr. Benjamin Gibbons, of Shut-end House, near Dudley, was then read:—

ON THE VENTILATION OF MINES.

The public attention has been much more directed within the last three or four years to the Ventilation of Mines, and a knowledge of the general principles has been more extensively diffused; the inquiry before the Committee of the House of Lords in July, 1849 and the Reports of the Mine Inspectors, since published, have thrown some light upon the manner in which most of the Mines are ventilated, and have pointed out some of the erroneous principles upon which many are conducted.

That this Paper may not be extended to an inconvenient length, the Author will confine himself as strictly as possible to the principles which, in his judgement, should never be lost sight of in the Ventilation of Mines, subjoining such illustrations as to some of the deviations in ordinary practice, that may be necessary to make the subject intelligible. He will also confine himself as much as possible to the Thick or *Ten-yard Coal* of the South Staffordshire

g from 24 to 30 feet in thickness;) observing at that the principles are equally available to the of other districts; for it is obvious that it is cult to drain the upper part of the Coal of the great 0 feet, of its Carburetted hydrogen, than that of This arises from the great *levity* of the Carburetted g out of the Coal, (which is the explosive Gas found) for it will always rise to the highest point as soon ; and it is plain that in excavating Coal of this large masses must be detached, and pockets or formed, which are instantly filled with this gas, in in which a level roof can be generally secured or e kept free from accumulations of this gas with much

er, 1846, in consequence of a frightful explosion Oldbury, the Author was induced to publish a small written *currente calamo*, and which described the Ventilation adopted and practised by him for many the thick and thin mines that were worked under perintendence.

ction of the subject was very unpopular amongst the Mines generally, who dreaded the threatened inter-ernment with their operations. This Work only er into the question of the Ventilation of the South hick Coal; but from the apprehension referred to or was assailed from all quarters; correspondents on-Tyne, Newcastle-under-Lyne, Shropshire, North s, containing Mines of very different character, and been alluded to by him, all united in one general such outrageous innovations; and if he had pro- from the Pope, a greater outcry could not have been said he was an ignorant innovator; others, a mere t was generally settled by these worthy philosophers t know what he was talking about, and pretty l that he was wrong on all points, and right upon

will first recapitulate the substance of a part of his

work, stating in addition the results of a confirmed experience upon a much larger scale, and a slight notice and reply to some of the the objections to his plan which had a plausible appearance (for he believes not one was real;) as he has since brought his plan as then described into uniform practice, and the methods of Ventilation that he recommended are now adopted throughout all his Coal and Ironstone Mines in South Staffordshire with complete success, and very satisfactory results both in working the Thick or Ten Yard Coal and the thinner veins.

The numerous and calamitous accidents caused by the Explosion of Gas in Coal Mines, which are unfortunately still so frequent and destructive both of life and property, render it an object of great importance for Mining Superintendents, Engineers and others, to invent some efficient and certain means of preventing the occurrence of these explosions; many plans have consequently been in practice for accomplishing this object, both by mechanical contrivances and by self-acting natural means.

That many sources of possible accident, and many of them beyond control, will still remain, especially in working a Coal of thirty feet in thickness, is most true; but it is the more incumbent, on this account, upon the managers of Collieries to provide the best practicable means against those dangers which they alone can remedy, especially that most appalling of all dangers, the imperfect Ventilation of the Mines. This danger being removed, a great diminution of the other accidents which indirectly arise from it would soon be experienced; and the Author is fully convinced, from the experience of many years, that this danger may be at once greatly diminished, and eventually almost entirely prevented.

The Carburetted Hydrogen Gas, which produces these dreadful explosions, is not explosive until it is united with a certain proportion of ordinary Air, say seven to nine times its volume; when this mixture has taken place, it arrives at what is termed its "firing" or explosive point, and in that state, if it come in contact with the flame of a candle, it will instantly explode with similar rapidity and violence to gunpowder. A considerable volume of this Gas is set at liberty in all the Thick Coal Mines, when worked in the usual manner, and as often as fresh masses of coal are cut through. Some

ply a much larger quantity of Gas than others, and only called "Fiery Mines;" but in all Coal Mines a ity is extricated to produce the most direful con- be not neutralised, or its escape duly provided for.
mode is that of diluting the Gas with a quantity of r; and a current of Air equal to thirty times the yielded by the Coal is, in the Author's opinion, the ety. That is to say, thirty cubic feet of common late through the Mine in the same space of time ll give out one cubic foot of Gas; but the quantity exceed this where this mode of Ventilation is copious supply of fresh Air is needful for the men, horses, and candles, employed in the pit.
nical plans have been recommended to increase the through the Mines for this purpose; some have ir pumps to force Air in, others exhausting Pumps out, and thus produce an artificial current of Air workings for the purpose of diluting and expelling s been allowed to issue into the workings. These lly may be very true; but it is to be observed, that Air must be constantly maintained, and in the tion, the Engine that works these Pumps or other ns may get out of order; a rod may break, a valve stick open when it ought to shut, and then what lives of those individuals depending upon the due part of the Machine. This fatal objection attaches l plans for ventilation; and indeed to all *artificial* e *power* of Ventilation is not *self-acting*, but requires *ion of Machinery* or the constant *aid of Men;* even dinary plan of rarefaction of the air by a separate be *out* when it ought to be *in;* and ought not to be he *sole protector*, though it will be in some circum- l *auxiliary*.
e should avail ourselves of the natural powers that nand as far as possible; as in this instance the r natural ascensive power of the Gas from which we Mines, supplies us to a considerable extent with

the remedy required. But cases may arise where other auxiliaries may be temporarily required from accidental displacements of the level of the mine; (though in the Author's opinion these cases may be reduced to a few, if the Mines are opened out and worked upon a proper system, as will be further noticed in this paper;) and under these circumstances, it may be necessary to employ Heat to rarefy the Upcast current of Air, to make it specifically lighter than the Downcast, or Mechanical means to force Air in or to extract Air from the mines may be required. Where Artificial Heat is made use of, a Steam-jet from the boiler of the winding engine is the most secure method, because the steam being supplied from the boiler of the winding engine, it is clear that the steam is always at command, whilst the pit is at work. If Mechanical means should become necessary, Mr. Struvè's exhausting cylinders supply the most powerful and effective apparatus that has fallen under the Author's notice.

The object of the present paper is to show that there is a *constant self-acting* power available, which experience has shown will afford the desired protection in ordinary temperatures, in the majority of cases; because the Carburetted Hydrogen of the Mines being less than half the weight of Common Air, (it has an equal ascending power to Common Air heated to 512 degrees, being of the same specific gravity,) will always rise to the highest parts of the Mine, and would escape with great velocity, if permitted to do so, forming in the aggregate a very large ascending power, as exemplified in the balloon; but in the ordinary system of working this escape is unprovided for, indeed absolutely prevented.

The ordinary system adopted in the Collieries of this district is shown in Plates 24 and 25; two shafts are sunk near together, about 7 to 7½ feet diameter, each to the bottom of the Coal, say about 180 yards depth; the two shafts commencing at the same level and terminating at the same level. One of these becomes the "Downcast pit," down which the Air descends, and the other the "Upcast pit," up which the Air ascends, when a communication is made between them at the bottom; but the only determining causes for the motion of the Air being accidental, it is unknown before hand what

rrent will take, and which will become the downcast
rally found that a current of Air does take place,
be said always takes place) without any other
nployed; but the determining power is so faint, that
e upcast pit with such trifling velocity, it is liable to
the action of the wind or by atmospheric changes,
nes happens that the Air becomes quiescent, or an
an, alternately ascending and descending the same
, in Miner's language, the Pits "fight," and the Air
cend nor descend with regularity in *one* direction.
l, the course of the Air will be sometimes inverted
that which should be downcast pit becoming the
e mine then becomes exposed to the most fearful
the workings have been opened, by the Air being
ds along the Airhead into the reservoirs of Gas
ipper cavities of the workings, and issuing into the
ged with the Gas to the firing point, causing an
hich many familiar instances might be adduced.

of this change in the direction of the Air current
creased by the *upcast* Pit being used as a *working*
cast Pit, which is in fact the *main* Gas and Air way,
nt always to be closed from the external air, and the
urrent guarded from disturbance or commotion, to
htest *interruption* to the current of air upon which the
end, is kept in a state of constant agitation by the
cent of the "skips" loaded with Coal, which nearly
To crown this, when every skip arrives at the top of
riage boarded over, called the "runner," is wheeled
of the pit whilst the Coal is landed, and then with-
the skip to descend. It is obvious that the air, which
be disturbed, is thus constantly liable to be in con-
ts more or less, sometimes upwards and sometimes
d whenever the Mouth of the Shaft is covered by the
is in a state of partial stagnation. But it sometimes
e chain or tackle by which the skip is suspended
he ascent in the upcast Shaft; the skip then drops
, drives the air before it with great velocity along the

Air-head, and forces the Gas out of the cavities into the Workings downwards upon the candles of the workmen; and this the Author has known to happen many times.

When the two Pits are sunk down through the stratum of Coal 30 feet in thickness, a "Gate-road" or Horse-way is next driven in the bottom of the Coal from 8 to 9 feet high, and about the same width, commencing from the bottom of the downcast pit.

At the same time (or rather before, as it should always precede the Gate-road) an Air-head is driven about the *middle* of the Coal, or 15 feet high from the "floor" or bottom of the Coal, commencing from the downcast pit. The Gate-road and Air-head are then driven in parallel lines at the same level upon which they commence, for the distance of 100 to 500 yards or more, according to the quantity of Coal intended to be cleared by the Pits.

A series of "Spouts" or openings are driven *upwards* from the Gate-road into the Air-head at intervals of each 10 or 15 yards, (as the Coal may give out more or less Gas,) which carry off the Gas, and produce a current of Air for the workmen, each spout being closed up when a new one is made in advance. The excavation of the whole thickness of the stratum of Coal 30 feet thick is then proceeded with, by opening right and left from the end of the Gate-road, and excavating a "side of work" which forms a square cavity, say about 90 yards long by 50 yards wide, or about an acre; the whole of the Coal being taken away as far as practicable, excepting the "Pillars" of Coal, generally 10 yards square, and 10 yards distance from each other, which are left to support the superincumbent strata.

The Air descending the downcast pit, and travelling along the Gate-road into the Workings, ascends to the Air-head, and traversing that, ascends the upcast pit, carrying with it the Gas and impure vapours, as far as such imperfect and interrupted means will effect, and delivering them into the open air.

By this plan, we may contrive, where this system is adopted, to ventilate the mine, though imperfectly, until the lower 15 feet of the Coal is excavated; but where the whole thickness of the Coal above the Air-head has been removed, by undergoing the Coal from the bottom, and dropping it down in large masses, the upper portion

eing above the level of the Air-head forms a reservoir gradually accumulates, and has no means of escape; he capacity of some hundred thousand of cubic feet, wholly or in part occupied by Gas. An accidental current of air, the direction becoming reversed as d, which does occasionally happen, (arising from such as mere changes in the atmosphere, as well as tioned before, of the breakage of the tackle, and the skip down the shaft,) would turn the course of the Air-head into this reservoir of Gas, and from e Gate-road; and then, if a portion of the air became as to the firing point, an explosion would inevitably he Coal is extracted, a solid wall or "rib" of Coal, ards thick, which is commonly termed a "fire rib," is he chamber, separating it from the next workings, ce from the Gate-road is securely walled up to exclude revent spontaneous combustion, which would other- period take place. When an explosion occurs, it is wed by a second or more, as portions of the Gas sively charged with the due proportions of Air; and these terrible explosions will always remain in mines ill by some efficient means the Gas can be allowed a ape by its own levity, and a current of air for the oses of life and light can be ensured to move always , with *sufficient power* to overcome all extraneous dis either of the wind or any atmospheric changes.

d 27 show the system adopted and carried into opera- hor. One Pit only is sunk instead of two, and in the ft a smaller shaft is cut to form an "Air Chimney," ds separated from the main shaft; this Air Chimney ay be made about 3 feet diameter inside, or more, as d. This is done simultaneously with the sinking of it very little impedes the rate of sinking, as an has room to work in it, and he keeps pace with the shaft. This Air Chimney is bricked at the same Shaft, the circular brickwork of each forming a parti-

tion of double thickness and secure strength, from the two arches abutting against each other.

This Air Chimney is carried from the top to the bottom of the Shaft and is sufficient to carry off all the Gas and such quantity of Air as may be required in the mine. The men carry always an abundant supply of air *with* them, and the efficiency of the Air Chimney is strikingly displayed in sinking the Shaft; when the ordinary pits are sunk, after a charge of Gunpowder has been fired in blasting such measures as require it, (and most of them do,) a considerable space of time elapses before the smoke is sufficiently dissipated to allow the sinkers to descend and renew their work; but when the Air Chimney is used the smoke is at once dispersed, and before a man can reach the bottom of the Shaft, it is carried away by the Air.

The Gate-road is driven from the Shaft at the bottom of the Coal as in the ordinary plan, but the Air head is driven from the Air Chimney within two feet of *the top of the Coal*, or higher if practicable, the vertical Air Chimney terminating at the level of the horizontal Air-head. The Gate-road and Air-head are carried forwards in a parallel direction to the extent of the work, as before described in the ordinary system; and "Spouts" or openings are driven upwards to connect them, at about every 15 yards, in the same manner as before described, every spout being bricked up close in succession, when a fresh one is made in advance, so as to make the current of Air traverse the whole extent of the Gate-road before it rises up to the Air-head and passes away to the Air Chimney. These spouts can only be driven perpendicularly *upwards* from the Gate-road to the Air-head, and each of them being about 18 feet long in the 30 feet Coal, a formidable practical difficulty was experienced by the Author in the King Swinford Pits, where the Coal being contiguous to a great fault, it abounded in Gas to so great a degree, that when a spout was carried up a very few feet, it became so filled with Gas that no man could work in it. But to show how small an aperture is necessary for the escape of the Gas in its undiluted state, this difficulty was overcome by boring upwards from the spout a hole four inches diameter into the Air-head; the Gas fled off instantly, followed by a stream of Air sufficient to ven-

ad and to enable the men to work with Candles in
erfect safety.
on of the Coal is commenced in the same manner
y system, by driving at right angles from the end of
begin a "side of work," and the ventilation is
etely and continuously from the extremity of the
he whole of the Coal to the top is removed. The
is *constantly drained off* from the *upper surface* of
ne Air-head and the numerous spouts or cross
emain all open to the Air-head by means of a
eft in the stopping as they are successively stopped,
ntly *drain* off the Gas most effectually, by piercing
ing the horizontal layers of Coal, and thus tapping
at so many different points. The process resembles
a bog of its water by cutting two main parallel
ding the whole into a series of square portions; but
pe with a greater facility than water, and is carried
ity, causing a rapid current in the Air-head without
an artificial current of Air, as fast as it is released
f fresh masses of Coal, which is a circumstance
cessary facility for rapidly draining the Coal. By
langer of any accumulation of a reservoir of Gas in
e upper part of the workings is effectually prevented.

is lighter than the Air must have been known ever
been worked; but, as far as the Author's knowledge
practical mode has ever either been adopted or re-
ect the purpose of draining off the Gas. Boring holes
hrough the Coal was one plan suggested; but inde-
itter inefficiency of the plan, the expense would be so
it that wholly out of the question; added to which, the
almost all instances filled up, either by earth falling
water lodging in them, which would render them

which has been suggested, has been to drive an Air
und the area of Coal which has to be got, in the same
ight be made round a fortified place; the Author

believes it is all but impossible to drive such an Air-way at all; but, even if it could be driven, it would be perfectly useless; such an Air-way would not drain the Coal to 10 yards distance, and would leave the whole interior of the mine intended to be got charged with Gas in its original state; and unless the whole of the horizontal veins of the Coal were cut through, from the top to the bottom of the Coal, the Gas would not be extracted from the Coal, even within that distance; consequently, this plan may be pronounced equally impracticable and useless; for it cannot be too frequently impressed upon the attention, that Gas will not pass *vertically* through the Coal, but only from the *horizontal* layers or divisions.

A Plan was suggested by Mr. Ryan to drive a Gas drift along the cross or upper edge of the area of the body of coal intended to be worked, or encircling the coal in some cases, under the mistaken idea that the Gas, from a distance even of a mile or more, would rise to the highest point of the Mines, and the Coal be thus gradually drained. Laying aside the question of expense, which would be a sufficient objection, such a Gas Drift, even if it had intersected the Coal through the whole thickness, would have had no effect whatever; for nothing short of dividing the Coal into sections or squares of not more 15 yards thickness would be of the least service, and that must be done vertically and horizontally, for the first Slip or Black Face will intercept the release of the Gas, as any smooth face forms an impervious barrier to its passage.

In the ordinary system of ventilation, it is manifest that only a very slight determining power compels the Air to travel constantly in the same direction; its current is at all times weak and insufficient and liable to be deranged by the action of the wind or atmospheric changes, and it is under no *command* whatever. To ensure safety a constant current of Air is indispensably necessary; it should be a current, too, maintained by natural causes, as far as possible, and never interrupted, for the reasons already assigned, and should be one that will not vary or fail.

To effect this, the *ascending* Column of Air must be rendered specifically lighter than the Air of the *descending* column, which ci

the workings, and this difference of specific gravity
ined constantly *free from disturbance* by accidental
uch an extent as to produce under all circumstances
of *propelling power* that is found sufficient for the
ation of the mine. This is accomplished by con-
ole of the Gas in a continuous *ascending column*, free
on or disturbance up the *separate Air Chimney;* and
power is further increased by erecting a "Ventilating
sufficient height on the surface of the ground, into
ch the Air Chimney is continued, so as to form one
Air-flue from the top of the Ventilating Chimney
r-head in the seam of Coal. By this means a long
shown that a *constant draught* is established and
ne occasional aids of a small Furnace or Steam Jet,
sufficient in all ordinary cases to defy wind and
so to produce a current sufficiently strong that it may
ch portions withdrawn from the main stream of Air
nd requisite to carry on the preparatory work to
et of Coal.

the Gate-road and Workings is warmed above the
the Air on the surface, in ordinary mean temperatures,
he earth, and is consequently rarified; this is aided
an would be generally supposed by the heat pro-
e numerous workmen, horses, and candles, employed
nd the further current caused by the escape of the
e specifically lighter than the Air. The Air-head
nterrupted and continuous passage into and through
ey from the Workings, and delivered into the Ven-
ey, and a draught is constantly maintained sufficient
rposes. The weak power of draught that exists in
is materially diminished by the *upcast* shaft being of
an the Air-head through which the air must pass, and
xternal Air, and thus cooled down below the tem-
Air after it has travelled through the mine. The
ent in consequence of the large area of the upcast
red with the Air-head is languid and slow, which is
d objection: whereas, in the Author's judgment, the

ascending current should have *considerable velocity*, and much more important advantages arise from this cause than philosophers either account for or will admit.

Cases may occur in which it is desirable, for temporary purposes, to *increase the draught*, either when the external air is at a very high temperature or from other causes, and this at once obtained by adding a Furnace or a Steam-jet of any required power to the Ventilating Chimney; by means of a fire in this furnace any degree of rarefaction may be produced that is desired in the Ventilating Chimney, and it is recommended always to build one, where the Boiler Chimney cannot be used, that it may be used if it is wanted. In such cases, the flue of the furnace should be carried up perpendicularly for 30 or 40 feet against the side of the Ventilating Chimney, before it is opened into it; this precaution will render a deflagration of the gases passing up the Chimney impossible when the furnace is used. It is in most cases practicable to make use of the Chimney of the Winding Engine as a Ventilating Chimney by making it of sufficient dimensions, and dividing it into two equal parts, by a wall of about 30 feet high; this being always in a heated state, acts very powerfully and efficiently, one division ventilating the Pit and the other being appropriated to the fire of the boiler. This plan has been adopted by the Author at all his Collieries, as he has in all cases the Chimney of the Winding engine built of sufficient dimensions, and divided in the centre by a wall half brick thick. An additional means of increasing the draught when required, is also afforded by inserting a steam-jet from the boiler into the ventilating compartment of the Chimney, and where high pressure engines are employed for winding, the steam is discharged from the cylinder into the ventilating compartment for this purpose, producing a powerful draught as in the case of the locomotive engine. However as in case of repairs of the boiler and its brick-work, the ventilation *might* be for a short time *disturbed*, although no danger need be expected to arise; such is the great objection to any breach of the system, however slight, that the Author would think it prudent to erect a *separate* Ventilating Chimney to be kept in *reserve* with a furnace attached for important Pits, to be used when the Ventilation of the Boiler Chimney is thus suspended.

casions, temporary departures from the *Rules* laid
navoidable; but these cannot be termed *breaches of the*
up and down-casts, mucky or rotten coal, interpose
must be removed or provided for in the best manner
nd experience of the Mine Director can discover, for
o rules or regulations can be insisted upon, except
care to abridge any necessary departure from the
-establish it as quickly as possible. It is by no
sual practice to depress the Air-head in parts, and
gain to its former level, under the erroneous idea
ill, like water, regain its level; but it will not, the
descend, and a serious interruption to the proper
ne mine is interposed.

le of Ventilating Pits by an Air Chimney, used for
than the passage of the Gas and the current of Air
ings to the surface, has been adopted by the Author
ss perfect form for more than thirty years in working
Thin mines, and has been found to give a complete
nmand over the ventilation of every part of the mines.
ever, within the last few years that he has had an
carrying it through many extensive Pits systema-
e whole of the Author's mines, this system of
ow completely carried out; the Thick Coal is some-
n one Pit, and in another Pit Brooch Coal, Heathen
ite Ironstone lying beneath the Coal, and sometimes
l is worked in both; very little preparation is
is change from one to the other, as the Air Chimney
lowest vein, and a stopping being put in at the level
nded to be got, a supply of Air may be immediately
required Level. The Thick Coal *abounded* in Gas
but it is now so *drained* that all difficulties have
e use of the Safety Lamp has become a form rather
; but it is never suffered to be neglected, as it tends
its of care and circumspection in other cases.
rovement has resulted to the *health* and *comfort* of
nployed. The Air in these Pits is always free from

gas, and is ten degrees (Fahrenheit) cooler than the neigh Pits, worked on the ordinary system, owing to the regular of fresh Air. They have been frequently tried, and found to 64 degrees in the Workings, whilst at the same time th the Workings of Pits ventilated in the ordinary way, was f many cases to be 72 to 74 degrees ; the former, the temper a comfortable sitting room, and the latter, that of a heated mill.

A very great saving of expense from this system will b also, not only in working the Thick Coal, but subsequ getting the thinner veins of Coal and Ironstone. A very cons amount of outlay, as well as frequently a great loss of tim curred in obtaining the necessary supplies of air for working cessive strata of a mine. Whereas the Air Chimney is acces any point in the Shaft, and the Shaft is *always* kept well aired is of importance, as it is often found convenient to susp workings of the Pit for a considerable time after the par haustion of one of the strata, and before it may be desirable mence the working of another. The Pits with the Air C have been always found to be in a perfectly well aired sta quite safe to descend and commence new operations in a day's after the suspension of the workings for several years. A ve siderable saving will be found to result from this circumstance the whole of the strata are worked out, where the strata are nu It may be observed here that an Air Chimney may be very cut down any Shaft which has been sunk in the usual wa Author has cut one down a Shaft during the night, whilst still continued to draw coal during the day ; he executed on pit 140 yards deep in about a month, the pit continuing t coal during the day, whilst the air chimney was made in the

Where large quantities of coal are to be drawn a num Shafts are necessary ; two of these may be sunk at the usual d of 10 or 12 yards, near enough to be commanded by the Winding Engine, but the Shafts having no communicatio each other. But if the form of the mine makes it more conv they may be sunk singly in any required situation, becaus separate Shaft will provide its *own Air*, and each Shaft will

separate section of mine appropriated to it; (by this means all detached portions of mine have been got to advantage, that ld not have paid for the expense of two shafts.)

By this arrangement, a much smaller quantity of Air-heading is ired to "get" the same area of Coal, and the process of complete tilation can be more easily carried out, as will be hereafter ced; and although communications between different Shafts by Gate-roads might be occasionally convenient, these communica- s may be under the care and sole control of the Mine Director, may keep the doors locked, if advisable; the Ventilation is not materially disturbed.

In the different plans for Ventilating Mines, the merit appears to been awarded to those more especially who have succeeded in *ng*, by any means, either mechanical or by the use of powerful aces, the *largest possible quantity of Air* through the workings in ven time. The principle explained in the present paper is ly different and diametrically opposite, for it is grounded on ning the gas away from the coal *before* it is worked, and then ing the coal when it is thus drained, and carrying *no more* Air ugh the Mines than is required for light, life, and health, it is founded on the old maxim that "prevention is better than ."

It is perfectly true that if a Mine supplies 1000 cubic feet of Gas minute, then, and in such case, 30,000 cubic feet of Air per ute must be passed through the workings in order to dilute it e point of safety, and to make safe provision for the varying umstances of change of atmosphere which may slacken or affect entilation; that is, if the Gas is allowed to *pass through* or into Workings at all. But the principle advocated in the present er is to *prevent* the Gas passing into or through the Workings, to allow it to escape by proper passages made above the where the Men work, and to allow it to *pass away* by its levity, which it speedily and rapidly does, if proper outlets are ided for its escape in the highest part of the Mine. That is to supposing, as a general illustration, that 1000 cubic feet of Gas minute is emitted by the Coal and *passed through the workings*,

35,000 cubic feet of Air per minute must by some means be forced to pass through the Mine; namely 30,000 feet to dilute the Gas and 5,000 feet to supply the workmen, horses, and candles in the workings; but if the whole of this 1,000 feet of Gas can be carried off by its own levity, and intercepted from passing *into the Workings*, then the Mine will be better and *more safely* ventilated by 5,000 feet of Air per minute than by 35,000 feet in the former case; or, if the whole of the Gas cannot be intercepted, then in such proportion as the volume of Gas can be intercepted and carried away. And supposing the opinion of the Author to be correct that the Gas can be carried away without passing into the workings, and that, therefore, a very greatly reduced quantity of Air is necessary in the Mine, it follows, that the Gas being of the same specific gravity as Atmospheric Air heated up to 512 degrees, that, when the Gas becomes diffused and united with the Air, the volume of Air and Gas so united, is of less specific gravity than the Air, and will maintain a *natural* Ventilation of considerable power. It may be observed, also, that very rapid currents of Air through the passages of a Mine, are always attended with great inconvenience to the workmen, and may be attended with great practical danger, from the circumstance that the union or perfect admixture of the Carburetted Hydrogen with Atmospheric Air, though very rapid, is not instantaneous: and when in a Mine not previously drained of its gas large quantities of the Gas suddenly escaping from powerful "blowers" are driven forwards by a current of Air moving seven to ten feet per second, it is very conceivable that they are not diffused at once, but carried, in some degree like a cloud of steam, forwards through the Mine, till diffusion has brought a portion to the "firing point," and then meeting with a light, or even driven (as they may be) through the wire of the safety lamp, will explode.

Many cases of explosion have occurred, where evidence has been given of the Mine being well aired, and the cause of the explosion has remained unexplained, and not even, with any reasonable probability conjectured; but the Author suggests that it may very possibly have arisen in some instances from this cause; and unless the rapid movement of the air can be proved to be indispensable, a slower rate of movement would be far preferable, both for convenience

safety. And the Author is particularly desirous to impress upon attention this circumstance, that if the Gas is carried off, and in sequence the Volume of Air necessary for the safe Ventilation of Mine can be reduced as much as five-sevenths, or even three rters of its Volume, that the Air-heads may be safely reduced in r dimensions in a proportionate degree, and yet remain equally tive; and as no Gas is mixed in the Air, the Workmen will be itely more secure. An objection that was made to the tion of the system, was the possibility of some disturbance of brickwork which separated the Air-Chimney from the main t, either by a violent blow from the ascending skip, (which of se could not be the case with the guides, that are now generally ,) or by any accidental explosion that might take place in the e, which it was contended might force it outwards into the main t. A mere inspection of the plan must convince any practical n that such an occurrence is impossible ; any force from out would be resisted by the convex surface of the Arch which ses the small Shaft, as any operating from within would be as ually resisted by the convex surface of the main Shaft. Not did no such occurrence ever take place in the numerous pits e the plan has been used without guides, but even where the Chimney was cut square, possessing so much less resisting r; and they remain now perfect and uninjured after a lapse of than thirty years.

nother objection was that the Air Chimney was not of sufficient nsions to ventilate the Mine; (and this objection was urged re-urged in the face of the fact, that the Author had expressly l that cases might occur where even a seven-feet Air-shaft t be required and employed to drain very fiery mines.) The es making this objection did not happen to recollect, that in fact *Air-Chimney* was precisely of the same area as the *Air-head* h they themselves always employed to form the communication een the workings and the upcast Shaft. That in fact the Air-mney was neither more nor less than a continuation of the ead from the workings to the surface of the ground; conse-tly they fell into this glaring absurdity, that it was necessary ve an upcast shaft with an area equal to about 38 square feet to

form a communication between the external air and a downca
containing an equal area of 38 square feet, whilst the Air-h
only Channel which connected these two shafts, (with a le
perhaps 1000 yards) and through which the descending air w
pelled to circulate before it arrived at the upcast Shaft co
an area of only 7 or 9 square feet. The effect of this was to d
the velocity of the ascending column in the upcast shaft, to
increased temperature the Air-head acquired in passing
the mine and the great advantage of *equal* velocity in the as
current, and by that means to materially reduce even th
ventilating power that had been obtained.

Another objection was, that in some of the thinner veins n
Air-head could be driven at a sufficient height to allow the gas t
by its own levity, or to prevent it from getting admission to the W
There may be exceptional cases—as, for example, if a mine can
posed to lie upon a perfectly horizontal plane,—(but the Autho
saw an instance of a mine to any considerable extent answer
description; in all mines he has ever seen, the Coal forms some ang
horizon in some direction, and a very small angle will soon obtain
of six or seven feet, which is quite sufficient for the present pur
in that case the Air-head communicating to the upcast shaft may
always to ascend to the higher part of the plane, which will
sufficient to keep the mine clear from gas, by allowing it to pas
its own levity. But, even if such a case ever should occur, a rem
often be obtained, an instance of which has lately occurred to the
A disturbance in the Thick Coal vein was found, breaking t
through and throwing it into a trough 15 yards below its le
course if the Air-head had continued to follow the vein, it mu
been depressed below its level, the whole thickness of the Coa
would have formed a barrier against the passage of the gas,
inverted syphon, which the gas would not have passed. The
adopted by the Author, was by commencing an Air-head from
Chimney in another measure, the "Flying Red," that lay 2
above the Main Coal, and continuing it till it had passed over the de
point; a communication was then formed to the upper side
depressed part, which at once established a rising Air-head for th
of the Coal on the farther side of the depression. This is me

as one instance to show that it does not necessarily follow that the iples here recommended may not be carried out, in case of meetvith the ordinary upcasts or downcasts which exist in most Mines.

t may be perceived that the plan of Ventilation here recommended nbined. in some measure, with the method of working the mines, and be made more perfect and efficient by the adoption of a sound m. The common mode is that of working the mines in "panes," panels," leaving "pillars," or portions of Coal, to be extracted at a e period; but this is considered by the Author as not only highly tionable as opposing great difficulties to the proper ventilation of aine, but as compelling the Air to be carried through long and torpassages, and split into numerous currents, and thus reduced in locity to perhaps one foot per second, of which examples are given South Shields Report, and increasing the length of the Air-passage extent of 70 miles, and the air thus occupying 16 hours in sing the mines from the downcast to the upcast Shaft.

he danger of this method must be sufficiently obvious, when seen that the Air must be forced through these various ings in the most crooked and winding channels, and its course elled to pass along by artificial buildings, or "brattices," the accidental destruction or failure of which may suspend the e ventilation.

ut the plan exhibited will show that, before any Coal is got the mine in the method recommended by the Author, the s are carried out to the extreme extent that the Coal is osed to be worked, accompanied by their Air-heads; by this ns the complete drainage of the gas from the mass of Coal osed to be worked is effected, and these roads and their Airs are originally made at infinitely less expense, and are always safe and secure state, as the excavations commence at the ide of the Coal thus intended to be got; and that no brattices necessary, as double doors may be used in any of those roads which the Air is intended to circulate, either to regulate the tity, or prevent its passage; and the current of Air may be ys brought to act directly upon the working face of the Coal.

t may be objected that these pillars must be left for a support

owing to the nature of the roof of the mine; but this the Author has never yet seen, and is disposed to think that it never can happen. He is getting veins of Coal of thirty feet in thickness, (in two successive workings of 15 feet each,) also veins of six feet, four feet, and three feet thicknesses; the roofs of these various coals differ in their tenacity, and some of them are extremely tender, and yet the *whole** of the Coal is extracted from these veins, both the thickest and the thinest, both large and small Coal, with the greatest facility and safety; and if the Author was called upon to express a preference of any, he would prefer a tender roof to one formed of rock.

The dangers obviated by this mode of working are doubly important; the roof gradually descends as the mine is excavated; all dangers are left behind, and the roof is consolidated into a compact mass by the weight of the superincumbent strata, consequently no "goaf," or hollow, is ever formed, and no lodgement of gas can take place. Secondly, no large or small coal being left behind, the heating of the goaf, or the spontaneous combustion to which all mines are liable where small coal or slack is left, can never take place.

The Author, as observed at the commencement of this paper, wishes to avoid entering upon any remarks that may appear to censure any of the systems of getting mines different from that practised by himself. He does not wish dogmatically to assert that such systems may not be necessary in some cases, although it is not apparent to him why they ever can be necessary. Men of great science and ability, he is willing to believe, may have good and valid reasons for the adoption of the plans they pursue in particular cases;

* *Note.*—The extraction of the *whole* of the 30 feet coal was first accomplished in the collieries of James Foster, Esq., on the suggestion of George Jones, Esq., some years before any other person attempted it; it is, indeed, only carried out successfully at present by Mr. Foster and the Author. The Author is happy in having this opportunity of giving his testimony to the fact, and also to the credit justly due to Mr. Jones, for his bold and correct conception; and to Mr. Foster, for his sagacity and energy in carrying it out. The Author has shown (what might have been doubted) that this is done with perfect success, and that it is quite suitable to his principles of ventilation, and, indeed, is admirably efficient in *practice*, as regards the drainage of the gas from the coal.

t others may imitate their system where the same reasons that ay be urged in those cases do not apply. But, as the Author is epared to show that they offer very great impediments to a sound stem of Ventilation; that in case of accident they are attended th the most awful and distressing results; it would be inexcusable him not to make some remarks as to their disadvantages, for purpose of pointing out to the observation and attention of ose engaged in mines the propriety and necessity of making ese modes of working mines as *few* and *exceptional* as possible.

He has already observed that, in the mode of working mines in nes and Pillars, where a part of the Coal is of course left, and ntually lost, the difficulty of obtaining safe ventilation renders accomplishment nearly impossible; and upon this point he will y notice further the deplorable consequences that follow when accidental explosion takes place. At Newcastle-on-Tyne, the ttices being all blown down by an explosion, and the workings filled with carbonic acid gas, and no means existing of quickly toring the ventilation (which arises from the system employed, at the Felling Colliery and many other similar cases,) the s and Workings could not be entered, nor the bodies of men recovered for weeks, nay, even months. Every man in mine, though out of the reach of the explosion, necessarily t his life by the *after-damp*. A very recent case in Scotland, Nitshill, where sixty-one lives were lost, is a striking ex- ple; although this Pit had a good and distinct Upcast Shaft, Brattices were destroyed, the Air of course proceeded along the rtest and most direct road from the Downcast to the Upcast aft, and all the men who had been supplied with Air by the ersion of the currents, depending entirely upon Brattices which re destroyed by the explosion, miserably perished, and the whole the bodies could not be recovered in a week's time.

The Author will next allude to the sinking of Shafts of large meter divided by Brattices, and of such large dimensions as to ow one side of the brattice to form the Downcast, and the other Upcast Shaft. A similar result follows in the event of an losion to the recent case in Scotland mentioned above; a part

of the brattice (probably at a considerable depth) is ruptured, an
no current of Air can be procured to admit of its repair, except b
means which involve loss of much time and expense. In th
meantime, all those who may have been in the pit, at the time of th
explosion, cannot be approached. The Author presumes that som
idea of economy introduced this system; but he is satisfied tha
upon this point an erroneous impression has prevailed. Th
expense of sinking these single divided shafts, of the usual diamete
of 15 or 16 feet, is so very great, that it has led to the practice o
working very extensive areas of Coal by means of a single Shaft
and this practice has further led to the different scientific con
trivances for impelling the air over these immense areas, by which
the ventilation of the works is rendered so much more difficul
and uncertain.

Taking, for example, a Pit of this description, of 15 feet diameter
by which is worked an area of 200 acres, (and instances might b
adduced where four, five, and six times that quantity has been thu
worked,) it is self-evident that the ventilation of a Coal Mine o
this description, where the air passages have been extended to th
length of 70 miles, must be attended with very great danger an
vast expense.

Now the Author states as his opinion, and thinks he shoul
have no difficulty in proving it correct, that four shafts might have
been sunk on this Area of 200 Acres, 7½ feet diameter each, in prope
positions with their Air Chimneys, for considerably (he dare no
venture to say how much) less money than the one Shaft cost; an
if this can be established, it follows that the 200 Acres bein
divided into Sections of 50 Acres each, the expense of the under
ground work would have been most materially diminished, and that th
ventilation might have been effected with much greater ease and securit
in separate sections of 50 Acres each, and the power of raising Coa
doubled, as there would be always two ascending and two descendin
corves, instead of one.

It may be alleged, that these larger Shafts are sunk with mor
facility, in consequence of the nature of the strata through which th
pits are to be sunk, or the occurrence of quick or running sands of grea
thickness; but it is under these very circumstances that the facility an

ng of expense in sinking the smaller shafts is most strikingly ifested As an example, we will take one of the most formidable ulties, that of sinking through a great thickness of running sand. , in the sinking of the smaller shaft, entire cylinders or tubs of cast descending by their own weight, may be used, excluding the sand ey descend; and, provided it is previously ascertained how thick the may be expected to be, sand of any depth, even 100 yards may be through, by putting in the first tub of a size sufficiently large, so that stopped, as it probably will be in 10 or 12 yards of its descent, by riction of the sand, a second may be sunk within it, and so others in ession, (like the inverted tube of a telescope,) till the sand is penetrated e sound measures. (See Fig. 3, Plate 24.) A running sand mixed water was sunk through by the Author's advice, more than 20 years ago, lopting this principle, in a shaft of 7½ feet diameter, and although and was between 35 and 40 yards in thickness, and of so fine and ite a character that, when dried, a great part would run through an nary hour-glass. Now, the Author cannot see how, in a shaft 15 or et in diameter, entire cylinders can be used, certainly not without nous expense, and if they are to be joined in parts, (which must be down in the pit) the expense and difficulty attending in that case removal, and supporting of the ground until the cylinder is com- d, must be enormous, which those engaged in such works must well by bitter experience.

Now, with regard to the Ventilation, which is more immediately the t of the Author in introducing these remarks, it is obvious that, by ng four shafts in the proper positions, this area of 200 Acres, is ed into four sections of 50 Acres each, and thus by shortening the passages, and dividing the portion of the gas furnished by the mines four parts, and having the Coal drained by four distinct and rate channels, the ventilation may be safely effected with comparative and much greater safety.

Now, to sum up the conditions and principles to carry out the or's plan effectually, he would state—

st. That the Air-head should always open into the highest (prac- le) part of the mines.

nd. The Air-head (or what may be properly called the Gas-heads)

by which is meant the *horizontal* Air or Gas passage, shall alw
continuous communication from the Workings to a vertical Air-
or separate Shaft, of 3, 4, 5, or more feet diameter, whichever
required, but always of sufficient dimensions to carry off the
Air from the Workings.

3rd. That the Air-head, or Gas-head, shall not in any pa
course be depressed below the level of its opening into the Wor

4th. That the Air-Chimney, (of such dimensions as t
requires,) by which is meant the *vertical* air or gas passa
never be used for any other purpose than the passage of the c
the Gas and Air from the Workings to the surface, and that
be closed from the external Air till it arrives at its point of

5th. That the vertical Air-Chimney should be closed at the
separated from the Shaft, and should then be connected to th
lating Chimney, or the Chimney connected by an horizontal
the boiler, so that the current of air may not at any time be
or interrupted.

6th. That the Gate-roads should always be driven to the
point to which the Workings of the Coal are intended to be ex
that the Coal may previously be drained of its gas before an
gotten, by which means the Gate or Horse-roads, and the Air or G
may originally be made, and afterwards be maintained, at con
less expense in a safe and secure state, and the Gases be g
drained off, before it is necessary to get the Coal.

As the object of this Paper, as first stated, is for the p
expounding the principles which the Author considers prope
ventilation of Mines, it would be impossible, in the limits to wh
a Paper must be confined, to enter into those details which mig
wise serve to make the subject much clearer than the Autho
able to do. It will be here impossible to enter into those pa
which would be necessary to explain the different methods tha
adopted to carry out these principles under the various circums
slips, upthrows, or downthrows, or those changes which presen
selves in every considerable area of Coal. The Author must, t
confine himself to the statement that the cases are exception
than general, in which there can be any insurmountable dif
providing the remedy for accidental derangements of this des

ithout interfering materially with the principles recommended; that to say, provided competent knowledge of the dip, and the position, and y of the strata, is previously obtained by boring, or other means.

The Author once more wishes to observe, that he has no desire to ter into the disputable question of the proper method of working the ines in other districts of which he has not had personal experience; is prepared to believe that good reasons may exist why men of ience and talent have deemed the systems they have adopted to be ose most suitable for getting the coal advantageously in the districts ere these are employed. The remarks he has, therefore, ventured to ake upon them are strictly limited to the results of his own experience, d only in as far as they interfere with, or form an impediment to the ntilation of the mines, and in those cases where the nature of the erations appears precisely similar, and are conducted for the same rpose, and he would not have alluded to them at all except that they intimately connected with effecting that object of draining the s and ventilating the mines as it appears to him in the most secure d effectual manner, with an important saving of eventual expense. at the Author has arrived at the fullest conviction, in his own mind, at no plan of Ventilation can be safely carried out, unless more merous shafts are sunk and smaller areas of coal are worked by them; d he is likewise convinced that that system will be found to brace every consideration both as regards security and economy. The cessity of freeing the mines from *water* is recognised by every one; it is imperative that proper provision be made for this purpose, cause the mines *cannot* be worked at all until the drainage is effected; any good reason, then, be assigned why no provision should be de for draining the coal from the *gas* when it can be so easily ected, and also, when that insidious enemy inflicts upon the mine ner, if it is retained, a much greater pecuniary loss eventually, and o what is of still greater importance, the loss of life to those meri- ious and industrious men, who have a right to demand at our nds every security that can be afforded them.

Mr. CLIFT inquired whether, in a colliery of considerable tent, Mr. Gibbons would always sink the shaft at the extr outside, in the highest point of the strata, for draining the gas, or in the centre of the area, so as to have the work l all round the shaft; and whether, in a large work, the air-h would not in some part have to descend towards the shaft.

Mr. GIBBONS replied, that he would always sink the shaf the extremity of the work, at the highest point of the coal st so as to drain off the gas from the whole of the coal; and he d the air-heads, always ascending, towards the shaft, interse the coal strata every fifteen yards with vertical passages, thro which the gas was constantly drained off into the air-heads.

Mr. COWPER wished to know if the shaft was sunk at highest point of the strata, how the water was carried off?

Mr. GIBBONS explained, that where it was required, he s a water-pit for the drainage at the lowest point, so as to drain *water* from the *lowest* point of the strata, and the *gas* from *highest*. He considered that 5000 cubic feet of air per mi were more than sufficient for any area of colliery that ought t worked by one pit, provided the gas was previously drained f the coal in the manner he had described.

Mr. SHIPTON supposed that the nearer the ventilating ch ney was to the pit's mouth, or the shorter the horizontal air was, the greater would be the ventilating power.

Mr. GIBBONS said he found that made little difference, air-chimney being simply a continuation of the air-head, wh was already horizontal in the workings, and the distance to ventilating chimney being, in any case, quite insignifican comparison to the length of the air-head.

The CHAIRMAN wished to understand how Mr. Gibbons able to take out the whole of the pillars, as stated in his pape as to remove the whole of the coal.

Mr. GIBBONS explained, that he began in the middle of

ckness of coal, and worked the upper half first, commencing one extreme side of the work, and driving a series of parallel ds about thirty yards apart, through the whole extent to the osite side of the area of coal to be got; and he then worked kwards from the extremity, excavating the whole of the upper kness of fifteen feet of the coal, and taking advantage of the erincumbent weight of the roof to bring down the coal; the roof continued gradually creeping down, following the k, and filling up the excavated space that was left behind. upper half of the coal was all got out by these means, the roof all settled down filling up the space. He then eeded to work the lower half in a similar manner, by ing a fresh series of parallel roads at the bottom of the coal, mencing at the same line as that from which the upper coal been worked. The roof was found to be settled down after fall, so as to form a new roof to the lower workings, quite and sound enough for the purpose; the first air-heads fell radually with the progress of the first excavation, being no er required; but the communication with the air-chimney at commencement of the work remained undisturbed, and the was left so porous after the fall, that the gas was constantly ng off into the air-chimney from the lower coal workings, as ily as water filtrates through a bed of sand. By this mode orking, a very large quantity of coal per day could be got at pit; it was only limited, indeed, by the winding power lable, as the face of the work could be extended at pleasure.

Mr. SLATE presumed, from Mr. Gibbons' paper, that the proion of slack obtained was less, and the coal more, than usually ined in the Staffordshire pits.

Mr. GIBBONS said he did not obtain any more slack per acre, a much greater quantity of coal By the old system, they got ıt one-third, and left two-thirds of the coal, but now none left.

Professor HODGKINSON remarked, that there were, no doubt, t difficulties in effectually securing the object discussed in the

able paper read by Mr. Gibbons. When so great an amount of matter was excavated from the bottom, there must be proportionately great settlement in the ground above. In the neighbourhood of Northwich, Cheshire, the brine melted the pillars that were left in the salt mines, and sinking was constantly going forward; and when the pillars were wasted by time the whole ground settled down together.

Mr. ADAMS inquired where a coal mine was situated in a deep valley, how Mr. Gibbons would place the pit in such a case? Mr. Gibbons replied, that he would drain off the water downwards and sink a shaft at the upper level of the strata to drain off the gas.

The CHAIRMAN said there could but be one opinion upon the able manner in which Mr. Gibbons had brought the subject of coal-mine ventilation under their consideration. Of late years, the many fearful and frightful accidents which had occurred, owing to the accumulation of gas in coal mines, had rendered the question one of the highest importance, and any person who could suggest a remedy for an evil so disastrous in its consequence, would prove himself the friend of humanity. Proper ventilation appeared to be the only remedy, and he hoped the excellent paper that had been read would receive, not only from the members of the Institution, but from the public generally, that attention which it so justly merited. He moved a vote of thanks to Mr. Gibbons, which was passed, and Mr. GIBBONS expressed his willingness at all times to afford any explanation in his power upon the subject.

The following paper, by Mr. Joseph Beasley, of Smethwick, was then read:—

ON A NEW MACHINE FOR BLOOMING IRON.

The purpose of this Machine, which has been invented and patented by Mr. Jeremiah Brown, is to perform the process of Blooming the Iron from the Puddling furnace, which is usually done by Hammering, and in some instances by Squeezing; the

ect being to squeeze out the cinder from the puddled ball, and ompress the iron into a form ready for rolling into a bar, which one at the same heat.

The Machine is shown in Plates 28 and 29, and consists of e large eccentric Rolls A B C, placed horizontally in the ng holsters D D, the centres of the rolls being arranged in a ngular position, and the bottom roll C nearly central between two top rolls A B. These rolls all rotate in the *same direction* hown by the arrows, and are driven by a centre pinion E, king into three pinions of equal size F F F, fixed on the roll dles; in the present machine the driving power is applied ct to the bottom roll by means of the large wheel G, for the enience of carrying the main shaft under the floor—but it could pplied to the centre pinion, if preferred. The rolls are cast with their journals like ordinary rolls, and are driven in the al manner by coupling boxes and spindles H H.

The roll-faces are 16 inches long, and the bottom roll has strong ges at each end, 8 inches deep, between which the two upper work; the object of these flanges is to upset or compress the of the bloom, as the iron in the operation is elongated, and nds are forced against the flanges, which makes them square sound, as shown by the specimen of a bloom exhibited to the ing. The top roll A has a large hollow in which the puddled I, is placed by the puddler; and this roll carries the ball round, drops it into the space between the three rolls, as shown in 2, this space being at that moment at its largest capacity. three projecting points K K K, of the rolls immediately impinge the ball, and compress it forcibly on the three sides, and giving tating motion to the ball at the same time, they have a very erful kneading action upon the iron, squeezing out the cinder effectually, which flows freely away down each side of the om roll. The space between the rolls gradually contracts, from eccentric or spiral form of the rolls, thereby maintaining an easing compression on the iron on all sides and the ends, until liberated by the points L L L, simultaneously passing the bloom which falls down in the direction of the arrow, and is discharged the machine at the same moment that another ball is dropped

in at the top of the machine. The projecting teeth on the surface of the rolls assist this action, by seizing hold of the iron and kneading into it as it rotates; and these teeth gradually diminish in projection, the last portion of each roll being plain, and the bloom is consequently turned out in a smooth compact form, as shown by the specimen exhibited. The space between the flanges of the bottom roll is widened for a short distance beyond the point L, for the purpose of allowing the bloom to drop out readily, and admitting the fresh ball.

A provision is made to prevent risk of breaking the rolls by any unusual size of ball being put in, by means of the two large triple-threaded screws N N, which bear upon the journals of one of the top rolls B; a small pinion on the head of each of these screws works into a large pinion fixed between them, which has a horizontal lever fixed to it, carrying a balance weight O at the end; this weight causes a constant equal pressure of the roll, and in the case of any ball of extra size being put into the machine, the screws yield by turning back and lifting the weight to the extent that may be required, so that a large ball will be worked with the same pressure and in the same effective manner as the smaller sizes. A continual supply of water is run on to all the journals throughout the machine, which prevents any possibility of the journals becoming hot, even when the machine is in constant work.

The advantages derived from this machine, are—

1st. The *saving of time* effected in the operation, as the machine makes five revolutions per minute, and turns out five blooms in that time, and consequently each bloom is only 12 seconds, instead of from 60 to 80 seconds, the time required in the usual process of hammering, being only about one-fifth or one-sixth of the time; the iron from the machine is therefore passed through the bar rolls at considerably greater heat than that from the hammer, and is consequently softer and better worked in that process.

2nd. The *saving of expense in manufacture*, as the machine is self-acting, and requires no men to attend the working; whereas, the hammer requires an experienced hammer-man in all instances, and sometimes two, depending on the number of furnaces the hammer has to work for, and these men are entirely dispensed with by the

machine being self-acting. An endless chain is also being added to the machine, working in an inclined direction from the lower side of the bottom roll, for the purpose of catching the bloom as it falls from the machine, and carrying it up direct to the bar rolls without any manual labour. In consequence of the machine turning out five or six blooms in the same time that one bloom is completed by the hammer, it is capable of working for a much larger number of furnaces, indeed for as many furnaces as can be placed within a convenient distance for working. Another important advantage from this circumstance is, that the puddlers are never liable to be kept waiting for their turns, as is often the case where one hammer works for more than 8 or 10 furnaces; on the contrary, with the machine, the greatest number of furnaces that can be arranged to be worked by one machine, will not be sufficient to employ it on the average more than one-quarter of its time, and consequently a very great margin is afforded for meeting the unavoidable irregularities in the supply of the balls from the several puddlers, which prevents the waste of iron, and deterioration in its quality that is caused when the puddler has to keep the iron back in the furnace waiting for his turn with the hammer.

3rd. The *saving of expense in tools*, which is very heavy where hammers are used; the hot iron being five or six times longer in contact with the hammer and anvil than with the machine, and the hot cinder out of the iron lying upon the anvil, instead of falling off constantly as it does in the machine; also the impossibility of applying a constant stream of cold water to the hammer as is done in the machine, cause the hammer and anvil to get so very hot, where a number of furnaces are working, that they wear out very rapidly sometimes lasting only a week, and are always liable to break, as also is the helve. The loss of time in replacing a hammer or anvil, when it breaks, or fails during the working, is at all times attended with loss in the quantity and quality of the iron, from being kept back in the furnace after it is ready until the tools are replaced; and when the helve breaks, the stoppage becomes a serious evil. The expense of keeping the machine in repair cannot be ascertained at present from actual experience, as the present machine at the Author's works is the only one that has yet been in regular opera-

tion for any length of time, and that only for the last four
this machine is standing the work quite satisfactorily, an
expense incurred since starting has been from an acciden
ing of one of the couplings soon after starting, through
manufacture. An effective provision is made to preve
breakage in the machine, by the driving clutch being ma
tionately very light, so as to give way before any other p
injured, and this can be replaced in five minutes at a
broken. The annual extra expense in repairs, and e
with a pair of hammers to do the same work, would
amount to as much as the total first cost of the machine.

4th. The *saving of power* with the machine, as the pow
exerted during one-fifth of the time required by the ham
during the greater portion of that time the power requi
machine is comparatively small, from the very soft and
of the ball, and the full power is not exerted until the re
nearly completed ; whereas with the hammer the power a
the same throughout the whole of the operation, as the
of the helve is lifted at each stroke of the hammer. Also
is required in rolling the iron from the machine, in conse
its greater heat.

5th. *Improvement in the quality of the iron*, in conseque
cinder being more thoroughly squeezed out of the iron,
enormous pressure to which it is subjected, and from the
kneading action of the rolls throughout the revolutio
machine whilst the iron is in a welding state, which u
grain of the iron more effectually than can be done by the
This action of the machine is *constantly* going on upon
but in the other case the *greater portion* of the time is *was*
lift and fall of the hammer, and this time is of great impo
the hotter and more fluid the cinder is, the more complet
be squeezed out from the body of the iron. The acti
machine is clearly shown by the accompanying Section
and it will be seen that the Ball is made to take a som
angular form, by the pressure of the three rolls, and t
particle of the iron in its turn is by the revolution of the
jected to the kneading action of the rolls, and is the

ssed in towards the centre of the mass, and again squeezed out-rds by the pressure that other particles are subjected to, thus ing great facility for the escape of the cinder from every part of ball, and forcing it out in a more effective manner than the linary process of working a four-sided bloom under the hammer.

There have been other machines invented on different principles, the purpose of blooming iron by a process of *squeezing* instead *iammering*, but the present machine is considered to possess im-rtant features of superiority, that enable it to surpass the hammer the quality of iron produced, on account of the above-described ion, which is peculiar to this machine; the certainty of the cinder istantly flowing freely away from the iron without risk of getting apped up in the bloom, and the perfectly uniform process that ry bloom is subjected to, whilst the quality of the iron worked the hammer depends entirely on the amount of labour and care towed upon it by the hammer-man.

Mr. Beasley exhibited a working model of the machine, and ious specimens of iron rolled from similar blooms made by the chine and by the hammer from the same heat of the puddling nace, to show the superiority of quality and greater purity from der in the iron made by the machine. Also specimens of a om from the machine and from the hammer, with one from the chine cut through the centre cold, to show the soundness of iron.

Mr. Cowper showed a sectional model, full-sized, illustrating kneading action upon the iron of the three spiral rolls, by the nge that took place during revolution, in the position of the erent points of a circular flexible hoop representing the ball iron, which was compressed into the triangular space between three rolls. He thought that, supposing the puddled ball ıld be taken hold of by the hand, and squeezed like a wet nge, that would be the most efficient way of separating the cin-

der; and the action of the machine resembled this process, by kneading the ball between the three revolving surfaces; but the hammer performed the operation by hammering all round the ball on each side in succession. If the iron was tender, by rolling it between two surfaces, as in the other squeezers, it was torn open, but in this machine, with the three rolls, the iron is more supported, and is subjected to enormous pressure, and the cinder is more effectually squeezed out from the body of the iron.

Mr. GIBBONS observed he had seen the machine in operation at Mr. Beasley's works, and saw many blooms made by it, and all equal to the sample exhibited; he should say that the specimens of iron produced were fair specimens of the iron made; and his impression was that he never saw iron turned out more perfectly. The operation of the machine was very satisfactory; and it was important for the blooms to be all worked in a uniform manner, and made of even surface.

Mr. SIEMENS said he had tried an experiment to ascertain the comparative power required to work the machine and the ordinary hammer, by taking the indicator diagrams exhibited to the meeting, of the power of the engine when working without any load, and then the power when driving the machine alone, and when driving the hammer alone; the indicator diagrams were taken at various periods of the revolution of the machine, to ascertain the average power, as the power exerted at the commencement of the revolution appeared to be very small, and it was mainly concentrated at the last portion. The average power of the engine was increased about 4 horse power whilst the machine was working, and about 6 horse power by the hammer; but as the former power was in action for only 12 seconds in the operation of blooming, and the latter was 60 to 80 seconds in action, the total comparative power in the two cases would be as 48 (4×12) to 420, (6×70,) or as 1 to 9, showing the power absorbed by the hammer to be nine times as great as that by the machine. This, however, might require some correction, on account of the momentum of the engine fly-wheel, from some

power being given out at the moment by its velocity being retarded; he could not detect any loss of velocity in the present case, but a more accurate measure might be obtained of any differential velocity, and he hoped to have an opportunity of making a more complete trial of the comparative power of the machine and the hammer.

The CHAIRMAN inquired whether there was not danger that the machine would lap up more cinder in the iron than was usually the case by the common process of hammering.

Mr. BEASLEY said there was not any danger of it, and he considered it was impossible, from the action of the machine, that any cinder could be lapped up in the iron, as there was no possibility of a portion of the iron getting lapped over in the process and enclosing some of the cinder in a pocket or hollow, which was, however, the case occasionally with the hammer.

Mr. WALKER remarked, that there were traces of cinder in the specimens of iron from the machine, and he thought there must be some portions of cinder lapped up in the process. He did not think the machine would be so effective as the hammer in extracting the cinder from the ball.

Mr. COWPER said he had carefully observed the working of the machine, and considered its action was very perfect. The iron was subject to an enormous pressure, and he was decidedly of opinion that no cinder was lapped up in it. He did not mean to say that the machine produced better iron than the hammer but it was at least quite as good.

Mr. B. WILLIAMS observed; that if iron was imperfectly puddled, the hammer would knock it to pieces, and show the defect in the quality of the iron; but he thought the machine would roll the iron all up, whether good or bad. He was of opinion that, from the rolling action of the machine, the cinder would be lapped up in the iron.

Mr. BEASLEY said, it was found that, if the iron was not properly worked, or was "green" iron, it was shown at once by the machine tearing it to pieces, although in other squeezers it might still be wrapped up into a ball.

Mr. R. WILLIAMS considered the cost of the machine, expense of keeping it in repair, would be an important con ration, and whether it would not be liable to accident and stop from its complication compared to the hammer. He though different sizes of balls would not be equally well worked, as were with the hammer.

Mr. BEASLEY replied, that the machinery was precisely si and not more complicated than the ordinary rolls, and no liable to go wrong. This machine had been working four m without accident, except one which was from an accidental in the original make; and he considered it was decidedl liable to stoppage and delay than the hammer. It wa intended to do away with the hammer altogether, but when sizes of iron were required, larger machines might be constr for such a purpose. The machine was suitable for all the va sizes of iron in ordinary work by using the regulating screw.

Mr. SIEMENS thought the machine would work and last from the small power required to keep it in operation.

Mr. SLATE observed, that the machine possessed an adva in being driven without the heavy cams and driving power re for the hammer.

Mr. WALKER thought the hammer was the best test o quality of iron.

Mr. BEASLEY said he had never seen a bloom fron hammer perfectly free from cinder in the regular work, and produced by the machine were decidedly more free from than those produced by the hammer, and they never had hollow in the body of the iron.

Mr. R. WILLIAMS remarked, that rolled iron was gen considered inferior to hammered.

Mr. BEASLEY replied, that the process performed b machine was very different to that of rolling, from the acti the three surfaces; he referred to the samples exhibited to the superior quality of the iron produced.

Mr. SLATE observed, that such specimens were not a true it depended greatly upon how they were broken.

Professor HODGKINSON said he had better acquaintance with the strength of iron than the process of manufacture; he had at first rather strong prejudices against the machine; he did not think it was exactly the right mode in which to get rid of the cinder, and it appeared to him likely to lap up some of the cinder; but he thought the objections he at first entertained were considerably lessened; the samples of iron from the machine, he must say, looked remarkably well.

MR. COWPER said he was, at first, much prejudiced against the machine; but his opinion was greatly changed since he had examined it in operation.

The CHAIRMAN observed, that the merit of the machine depended upon the relative quality of the iron produced, and there appeared a difference of opinion upon that subject. It was desirable that this point, as well as the cost of the different processes, should be ascertained, and laid before the Institution; and he, therefore, suggested that the inquiry and experiments should be further pursued, and the results reported to a future meeting.

A vote of thanks was passed to Mr. Beasley for his communication, and the discussion was adjourned to the next meeting.

The CHAIRMAN announced that the Ballot Lists had been opened, and the following new Members were duly elected:—

MEMBERS:

MR. JOSEPH BEASLEY, Smethwick,
MR. JOSHUA HORTON, Smethwick,
MR. JOHN STEWART, London.

The CHAIRMAN remarked that the subscription towards the erection of a monument to the memory of their late President, Mr. George Stephenson, was progressing favourably, and the Committee hoped shortly to be enabled to announce the nature of the memorial intended.

The Meeting then terminated, and the Members adjourned to the Library of the Institution, where coffee was provided.

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INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

SPECIAL GENERAL MEETING,

HELD IN LONDON, ON 30TH JUNE, 1851.

J. E. McCONNELL, ESQ., VICE-PRESIDENT,

IN THE CHAIR.

LONDON:
PRINTED BY WATERLOW & SONS, LONDON WALL.

MDCCCLI.

PROCEEDINGS.

THE SPECIAL GENERAL MEETING of the Members was held at the Rooms of the Society of Arts, John-street, Adelphi, London, on Monday, 30th June, 1851. The President, Mr. ROBERT STEPHENSON, having to attend a Committee of the House of Commons, Mr. J. E. McCONNELL, Vice-President, was called to take the Chair.

The SECRETARY read the minutes of the last General Meeting, which were confirmed.

The following supplementary paper by Mr. Joseph Beasley, of Smethwick, near Birmingham, was then read:—

ON A NEW MACHINE FOR BLOOMING IRON.

THE purpose of this machine is the blooming of the iron from the puddling furnace, in a more rapid, effectual, and economical method than is accomplished by the usual process of hammering or shingling; the machine is the recent patented invention of Mr. Jeremiah Brown (a roll-turner, late of the Oak Farm Iron Works, Dudley).

Other methods have been invented and employed to supersede the hammering process, some of considerable ingenuity and merit; still, unscientific ancient and rough as the process is, shingling or hammering obtains general preference in the blooming of iron; and it has been generally contended hitherto that the hammer excels all other means for ridding iron of its native impurities. This might perhaps be admitted with reference to all other methods hitherto introduced; but for the present machine, differing as it does in construction and action from any one hitherto contrived, there is claimed a decided superiority, in all respects, over the hammer and every other working process for the operation in question.

The blooming of iron is that process which the metal undergoes immediately upon its removal from the puddling furnace, whereby, as effectually and expeditiously as may be, the metal is consolidated

into a homogeneous mass, free from dross or cinder. The princi objection to iron made by the ordinary squeezers is the quantity cinder which is lapped or enclosed in it; whereas the object of sque ing compressing and hammering, alike is to separate and express cinder, which in proportion as it remains in the bloom, injures quality, destroys the fibre of the iron, and prevents it uniting i complete and uniform manner. It is the process of blooming, in f which fixes the character and quality of the iron, since no impu can be thoroughly eliminated by any after process.

This machine consists of three large spiral-shaped rolls, pla horizontally, and rotating all in the same direction; the ball of i from the puddling furnace is dropped into the three-sided space tween the three rolls, which forcibly compress the ball, giving i rotating motion; and they have a very powerful kneading action u the iron, squeezing out the cinder very effectually, which flows fr away down each side of the bottom roll. The space between rolls gradually contracts from the spiral form of the rolls, ther maintaining an increasing compression on the iron on all sides the ends, until it is liberated by the extreme projections of the r passing the bloom, which drops out of the machine at the same ment that a second ball is put in at the top. The journals of on the rolls are made to slide back to prevent injury when any extra of ball is put into the machine, and they are pressed down by a bala weight acting on two large triple-threaded screws, maintaining a c stant pressure on the roll, so that a large or small ball (within o nary limits) is worked with the same pressure, and in as effecti manner as the regular size of ball.

(See description and engravings of the machine in the Proceedi April 23rd, 1851, and Plates 28 and 29.)

This machine is simple and not complicated in its construction is moderate in the charges of its erection, and, as far as experi serves, safe and ready in its working, since not a single irregularit stoppage of the machine has occurred from the time it was starte efficient action, a period now of some months.

A most important advantage of this machine is the economy of effected in the operation of blooming. It accomplishes 5 revolut

per minute, and turns out one bloom in each revolution, which is at the rate of 12 seconds for each bloom; whereas the time required in the usual process of hammering is from 60 to 80 seconds per bloom, which is thus about 6 to 1 in favour of the machine. By this rapidity of the process of blooming by the improved method, the iron is passed through the bar rolls at considerably greater heat than from the hammer, and is in consequence softer and much better worked in that process, the rolling being performed in the same heat as the blooming.

A valuable consideration is the saving of expense in manufacture. The machine is self-acting, and requires no men to attend the working; whereas the hammer requires an experienced artisan in all instances, and sometimes two, and these men are entirely dispensed with by the machine being self-acting.

In consequence of the increased speed at which the bloom is turned out, being only one-sixth of the time required by the hammer, the machine is capable of working for a much larger number of furnaces, and the puddlers are never liable to be kept waiting for their turns, as is frequently the case where one hammer works for more than eight or ten furnaces. On the contrary, with the machine, the greatest number of furnaces that can be placed in proximity thereto will not be sufficient to employ it, on the average, more than one-quarter of its time, and, therefore, a very great margin is afforded for meeting the unavoidable irregularities in the supply of the balls from the several puddlers, thus preventing the waste and deterioration of the iron from being detained in the furnace until the hammer is at liberty. The writer may observe that he has not the slightest doubt, that iron for various manufacturing purposes, can be made from this process alone; he might instance iron for nail rods, which may be slit without extra heating, thereby avoiding both considerable waste and considerable cost and labour.

The expense in tools is very considerable where hammers are used, and is much greater than with the machine. In consequence of the hot iron being five or six times longer in contact with the hammer and anvil than with the machine, and the hot cinder out of the iron lying upon the anvil instead of falling off constantly as it does in the machine, likewise from the impossibility of applying a constant stream of cold water to the hammer, as is done in the machine; the hammer and anvil

get so very hot where a number of furnaces are working, that they wear out very rapidly, sometimes lasting only a week. They are always liable to break, as is the helve also, and in casualties of this kind the loss is always great. To replace a hammer or anvil when it breaks or fails during the working (particularly when a large number of furnaces are at work), is attended with heavy expense, and the quantity and quality of the iron much diminished, from being detained in the furnace until the repairs are completed and the tools replaced, which sometimes occupies a considerable period of time. In case of fracture of the helve, the loss sustained is still greater, involving as it does the total stoppage of the works until the helve is renewed.

The expense of keeping the machine in repair is very inconsiderable. The small amount of friction in its action and the slowness of its motion prevent any but moderate and trifling wear of the machine; and the maximum power employed in driving not being greater than that for the hammer, the liability to breakage is considerably less; that is, if the several parts of the machine are put properly to work. The machine at the writer's works, which is the only one at present in operation, has continued in constant work since it has been erected, about six months, with scarcely any outlay for repairs, except some incurred at starting, through defective construction of some parts of the apparatus; and the writer is of opinion that the cost of wear and tear will not exceed £20 to £30 per annum, whilst the expense of keeping in repair one hammer, to do half the work of one machine, would be more than ten times that amount.

An effective provision is made to decrease the risk of breakage in the machine, by the proportionately light construction of the driving-clutch, which will give way before any other part can receive injury, and which clutch, if broken, can at any time be replaced in a few minutes.

The saving of power with the machine is next to be noted. The power given out by the engine is only exerted by this machine during one-sixth of the time required by the hammer to do the same work, and during the greater portion of that time the power required in the machine is comparatively small, from the very soft and loose state of the ball, and the full power is not exerted until the revolution

is nearly completed; whereas, with the hammer, the power absorbed is equal throughout the whole of the operation, as the same mass of helve is upheaved at each stroke of the hammer. Less power also is required in rolling the iron from the machine, owing to its greater heat and softness.

For the purpose of ascertaining the actual power expended in working the machine, as compared with the hammer, the following experiments have been tried, and indicator diagrams were taken from the steam-engine employed to drive both the machine and the hammer, as well as the forge-rolls; these indicator diagrams were taken by Mr. C. W. Siemens, who kindly undertook to try the experiments with Mr. Marshall. During these experiments the engine was kept working at a uniform rate of 20 to 21 strokes per minute, and all the other machinery driven by the engine was kept out of use, and the engine was driving the same train of shafting and gearing in all the experiments, making a constant addition to the power exerted in each case.

Figs. 1 and 2, Plate 30, are a series of five indicator diagrams each, taken during the working of the machine alone, showing five successive strokes of the engine. In each instance a series of five blooms was got ready, and the machine was regularly fed with a fresh bloom at each revolution, for the purpose of keeping it in constant steady work, and neutralizing any accelerating force that might be felt at the commencement from the momentum of the fly-wheel of the engine, so as to obtain a correct indication of the power expended in working the machine.

Fig. 1 shows the whole power, from putting in the second ball to putting in the third ball, and fig. 2 from the fourth to the fifth ball of another series. The engine made $4\frac{1}{6}$ double strokes during one revolution of the machine, so that the five strokes shown in the diagrams include the whole process of blooming one ball in each case; but as the machine only compresses the iron during about 2-3rds of its revolution, in consequence of the hollow left in the upper roll for putting in the ball, the power of the engine is exerted only during three strokes in compressing each ball; and it will be seen by Figs. 1 and 2, that these strokes show a progressive increase of power was exerted, as the compression of the ball advanced, and the iron became

harder. The top line in Fig. 1 shows a very sudden increase of powe at the last stroke of the engine, indicating the final pinch or extrem pressure exerted at the moment of completing the bloom.

Figs. 3 and 4, Plate 30, show a corresponding series of indicato diagrams, taken during the working of two different blooms unde the hammer. The lowest line on Fig. 3 shows the power absorbed b the engine and shafting alone, before the hammer commenced working

The dotted lines in Fig. 5, Plate 31, show all the lines of Figs. and 2, Plate 30, reduced each to the same horizontal base line, for th purpose of comparing them together, and obtaining the mean of th whole, showing the working of the *machine alone.*

Fig. 6 shows a corresponding comparison and reduction of all th lines in Figs. 3 and 4, being the working of the *hammer alone.*

The full line E in Figs. 5 and 6, shows the power absorbed i driving the *engine and shafting only;* the mean of this is 3.70 lbs pressure per square inch, and this portion is shaded on each of thes Figs. 5 and 6, and also on the following Figs. 7 and 8.

The full line P on Fig. 5 shows the mean of all the indicato diagrams, so that the space between the mean total power P, and th power absorbed by the engine and shafting E, expresses the mea power actually expended in *driving the machine;* this averages 0.8 lbs. pressure per square inch, or $8\frac{3}{4}$-horse power.

Fig. 6 shows in the same way by the *full line* P, the mean powe expended in *driving the hammer,* and the average is 2.40 lbs. pressur per square inch, or $24\frac{3}{4}$-horse power.

But the machine completes each bloom in 12 seconds, whilst th hammer takes from 60 to 80 seconds for the same process. Conse quently, the comparison of the total power is 105 ($8\frac{3}{4} \times 12$), to 173 ($24\frac{3}{4} \times 70$), being a proportion of 1 to $16\frac{1}{2}$ in favour of the machine showing the power required to work the hammer to be $16\frac{1}{2}$ times a great as that required to do the same amount of work with th machine.

A similar comparison was also made between the machine and th hammer, when each was worked in combination with the forge-roll as is the case in ordinary working.

A series of five indicator diagrams was taken during the working of the machine and forge-rolls combined, with a continuous succession of ten balls passed directly from the machine through the rolls; the rolls could not, however, work fast enough for the supply of blooms from the machine, although three blooms were in the rolls at once, as the one machine would be capable of keeping up a constant supply of blooms for three pair of rolls. The *dotted lines* in Fig. 7, Plate 31, show these diagrams reduced all to the same base line, for the same purpose as Figs. 5 and 6.

A corresponding series of five indicator diagrams was also taken during the working of the hammer and forge-rolls combined, whilst one bloom was under the hammer and the previous one was in the rolls. These diagrams showed the highest pressure exerted during the operation, as the indicator dropped again to the lowest line in each instance after the completion of the highest line. The *dotted lines* in Fig. 8 show these diagrams reduced to the same base line as before.

The *full line* E., in Figs. 7 and 8, shows the power absorbed in driving the *engine and shafting only*, the same as in Figs. 5 and 6, this portion being shaded to correspond.

The *full line* P., on Fig. 7, shows the mean of all the indicator diagrams, and the space between the lines P and E, expressing as before the mean power expended in *driving the machine and rolls*, averages 7.13lbs. pressure per square inch, or 64-horse power.

The *full line* P on Fig. 8 shows in the same manner the mean of all the indicator diagrams, and the space between the lines P and E expressing the mean power expended in *driving the hammer and rolls*, averages 9.43 lbs. pressure per square inch, or 84¾-horse power.

The comparison of these results cannot be made in the same manner as the former results, from the machine and the hammer alone; as the time of each process of rolling was different from both of them, being about 40 seconds, and the iron from the machine could not be rolled so fast as it was bloomed; but it may be observed that the total increase of power exerted to drive the rolls was actually less in the case of the machine than in that of the hammer, although there were three bars in the rolls at the same moment with the machine, but only one bar at a time with the hammer; showing the great saving in the power required to roll the iron from the machine as compared with

that from the hammer, in consequence of its much hotter state whe brought to the rolls.

An important improvement in the quality of the iron is effected b the machine, which arises from the cinder being more thoroughly an minutely squeezed out of the metal in its progress through th machine, and from the powerful kneading and indenting action of th three rolls throughout the revolution of the machine whilst the iro is in a welding state, the effect of which is to increase the densit and solidity of the metal, and to unite and bind the grain of the iro more effectually than can be done by the hammer. This action of th machine on the body of the bloom is constantly exercised; but in th case of the hammer, the greater portion of the time is wasted in the lif and fall of the hammer, and this time is of great importance, as the hotte and more fluid the cinder is, the more completely can it be squeeze out from the body of the iron. The action of the machine is clearl shown by the accompanying sectional model, and it will be seen tha the ball is made to take a somewhat triangular form by the pressur of the three rolls, and that every particle of the iron, in its turn, is, b the revolution of the ball, subjected to the kneading action of the roll and is thereby first pressed in towards the centre of the mass, an again squeezed outwards by the pressure that other particles are sub jected to, thus giving great facility for the escape of the cinder fro every part of the ball, and forcing it out in a more effective manne than the ordinary process of working a four-sided bloom under th hammer. It may also be remarked, that when it happens that iro is not properly worked in the puddling-furnace, or is prematurel taken therefrom, the imperfect puddling is shown in this machine b large cracks or fissures in the bloom, or the bad portion is forced i irregular projections to the surface, and is not enclosed in the mass o the bloom.

Mr. Beasley said he had made some further experiments as to the strength of the iron manufactured by this process, as requested at the last meeting, and although they had been but few, they would be considered, he thought, quite satisfactory. Four bars, 1⅛-inch diameter, had been made in the same manner, and from the same iron, from the hammer as from the machine, both being made out of the same heat of the furnace. They were tested by Mr. H. Parkes' hydraulic press at Tipton for proving chain cables, and the first bar from the machine indicated a strain of 26½ tons before it broke. The first bar made by the hammer bore 27½ tons; the second from the machine, 26 tons; the second from the hammer, 25½ tons. He then tested two bars 1⅛-inch diameter, which had been piled; that from the machine bore 25½ tons, and the one from the hammer also 25½ tons. He also tried two bars of 1½-inch diameter, which had been piled; that from the hammer indicated 38 tons; that from the machine, 40 tons. It appeared, therefore, that there is no material difference in strength between the bars made from the hammer and those from the machine. But for other descriptions of iron he thought the machine much better than the hammer. He exhibited some specimens of hoops, of very tough quality; also specimens of other descriptions of iron, all bloomed by the machine.

A model of the machine was exhibited; also a sectional model, in which the operation was shown by a ball of putty.

The Chairman inquired whether Mr. Beasley had ascertained the relative cost of the two different processes of manufacture.

Mr. Beasley said he had not gone minutely into the matter; but it was known to every iron manufacturer that the expense of the hammer is very considerable, the wear and tear and the breakage of tools and helves, amounting to an expense of at least 1s. per ton. He found the machine saved in wages about 15d. per ton, besides the saving in power and in repairs; but in larger works the saving would be proportionately greater. Where there

were a great many furnaces to keep the machine regularly a work, the saving would be very considerable; but he had not sufficient number of furnaces adjoining the machine to keep fully at work.

Mr. Blackwell had seen the machine in operation, and wa convinced of its advantages. There was no doubt in his min that the cinder is more perfectly extracted from the bloom b the machine than by the hammer; and he thought there wa no doubt that the quality of the iron was better. He qui agreed with Mr. Beasley as to the saving in the cost of manu facture.

Mr. Adams had also seen this machine at work, and wa satisfied as to its efficiency; and believed the bloom was as goo as that produced by the hammer. But he found the cinde still exuded in considerable quantity from the two ends of th bloom, when it received an end blow under the hammer; an he thought a better quality than the ordinary iron from th hammer would be obtained by putting the bloom under th hammer immediately after it comes from the machine, to exp the remaining cinder.

Mr. Beasley thought that in the case referred to, the ba must have been below the proper limit of size, and consequent not fully worked in the machine; which would account for son cinder remaining. A variation of about 20 lbs. was allow from the standard weight of each ball (about 90 lbs.), whic was found quite sufficient with good puddlers, and was allowe for by the yielding of the weight on the screws of the machin The cinder was still in so hot a state, after coming from th machine, as to be squeezed out by the rolls, and the greate possible quantity of cinder was taken out by the rolls; so tha in fact, they effected what would be done by using the hamm in addition to the machine.

Mr. Blackwell thought the rolls squeezed out any remainin cinder, and remarked, as a test of the superior action of th machine in separating the cinder, that the yield under th

machine is less than under the hammer; the weight of iron produced, of course depending upon the quantity of cinder squeezed out.

Mr. Adams did not mean that the machine did not do the work as efficiently, and turn out as good a bloom as the hammer; but he thought that with the addition of the hammer a still better quality of iron might be advantageously produced than was at present manufactured, instead of reducing the expense.

Mr. Beasley exhibited specimens of blooms, of the ordinary make, from the machine and the hammer; he had had a considerable number of them sawn through and polished; and had not detected any flaw in those from the machine; he thought they were at least as free from cinder as those made under the hammering process, and that no cinder was remaining in the body of the iron. Under the hammer a lap was sometimes formed, by one of the edges of the square bloom being turned over, which is injurious to the iron, as it makes an unsound place or a hollow, in which some of the cinder is lodged, and cannot be driven out afterwards. A specimen of this kind was exhibited, a section of which is given in Fig. 1, Plate 32, showing the hollow in the body of the iron. Fig. 2 shows a good bloom from the hammer, and Fig. 3 the section of a bloom from the machine.

Mr. Cowper illustrated, by a model, the mode in which the iron is kneaded by the action of the three rolls, and the cinder squeezed out from the whole of the mass. He said that he had observed the working of the machine, and was satisfied that the cinder was thoroughly squeezed out from the body of the iron. The hammer often chilled the surface of the bloom, which to a certain extent, enclosed the cinder, but in the machine the cinder ran out very freely; and when that iron was rolled into bars, the cinder did not squeeze out of the ends, as is the case with the iron bloomed with the hammer; in fact so much so, that in rolling the blooms from the hammer the men always

stand on one side, to get out of the way of the cinder flying out of the ends; but with the blooms from the machine he had never seen any cinder squeezed out from the ends in rolling, or if any it was very trifling indeed, although the iron was in a much hotter state when rolled than that from the hammer.

Mr. Hodge said he could see the great advantage of this machine, but he thought the quality of the iron might be further improved by putting the bloom under the hammer after it comes out of the machine—but not the old style of hammer.

Professor Hodgkinson said he thought the machine was a most ingenious process; but notwithstanding the good appearance of the iron, he felt a doubt whether it was quite so efficient as the hammer in squeezing out the cinder; but he had not sufficient information to speak from, as he had not seen the working of the machine. The appearance of the iron was certainly excellent; and there was great ingenuity shown in the machine.

Mr. Beasley wished to make one other remark relative to the heat of the bloom as it comes from the machine. He thought it was possible to make a good weld under the hammer, of two of the blooms from the machine; he therefore tried two balls in rapid succession, and brought them to the hammer, when as good a weld was made as if the iron had been brought direct from the furnace. He believed iron manufactured in that way would save a great deal of expense in making rails; and the iron could be rolled at once without a second heating of the metal.

The Chairman observed that it was important that there should be a comparative test made of the quality of the iron as prepared by the machine, and that by the ordinary process of the hammer; and he suggested to Mr. Beasley to make a piece of iron, as well as he could under his process; and get another manufacturer to make a similar piece under the old process of hammering: the two specimens might be then submitted to Professor Hodgkinson for examination of their comparative merits.

Mr. Beasley said there might be a material difference in the quality of the specimens of iron, independent of the difference

in the process of blooming, which would interfere with the results of the experiment. But he should be glad to try the experiment of the two processes, by taking iron from the same furnace, at the same heat; and if one ball was taken to the hammer and another to the machine alternately, and then the iron of each tested, he thought that would be a fair trial. He would be ready to go through a series of experiments for the purpose.

Mr. Hodge thought Mr. Beasley's proposition would be the only fair plan of testing the two processes of manufacture.

Mr. Blackwell also thought the proposition a very fair one; and the comparison could only be made from the same starting point of the iron in the puddling furnace in each case. Even if the same ore were used, heated with the same description of coals, in two different furnaces, the working of the furnaces alone might make such a difference as to prevent the manufacturing of the same quality of iron in each, however carefully the materials were adjusted; and this would destroy the accuracy of any comparison.

Mr. Scott Russell remarked, that even if Mr. Beasley made no better iron by his machine than had been done heretofore by the hammer, he thought he had done a great deal in bringing the iron to a state to undergo the subsequent processes by more economical means.

Captain W. S. Moorsom hoped the experiment would also be tried that had been suggested, of obtaining an improved quality of iron by the subsequent process of hammering in addition to the machine, so that a material of greater strength might be obtained if possible.

Mr. Beasley said he would be glad to go into that matter; undoubtedly the iron might be improved for some purposes by subsequent hammering, as suggested; but for general purposes, he thought it would be useless, and an extra expense without any corresponding advantage.

The Chairman proposed that any gentlemen who felt inter-

ested in the subject should communicate with the Secretar and arrange the further experiments to be conducted at M Beasley's works, and bring the results before the Institutio

A vote of thanks was then passed to Mr. Beasley for his con munication.

The following paper by Mr. Paul R. Hodge, of London, w then read.

ON THE PROGRESS OF IMPROVEMENTS IN LOCKS I THE UNITED STATES OF AMERICA.

It is seldom that any skilful mechanical arrangement of parts carry out certain effects is the production of one mind, or one pair hands; nor do we find that mechanical genius is confined to one countr or any distinct race of beings. Perhaps there is no machine mor ancient than that of a lock; but it appears that, until about the yea 1774, very few improvements had been made in the construction locks in this country, although the basis or principle on which a modern locks are constructed can be traced back more than fo thousand years. The three principal locks manufactured in Englan for the last thirty years, are those of Barron, Bramah, and Chubb; tl inventions of each of which are based on the principle of the o Egyptian lock, the difference between them being only in the mech nical arrangements of parts to produce the same effect. The preser communication is intended to show the insecurity of English loc generally, and to bring under the notice of the Institution the ingenio lock of Mr. Newell, of New York.

It was conceded, about twelve years since, in the United States, b all locksmiths, that a lock having a series of tumblers or slides, such was used at that time in Europe, and more particularly those of Barr and Chubb, was secure against all known means of picking, or forming a false key by any knowledge that could be obtained throug the key-hole. The only point that seemed desirable was, to make secure against the maker, or any party who might have had possessi of the key, and from it taken an impression.

The first step, therefore, was to construct the lock so that the part using it could change its form at pleasure.

The most successful locksmith, for a time, was a Mr. Andrews, of Perth Amboy, in the State of New York; he constructed a lock similar to that made by Mr. Chubb, having a series of tumblers and a detector; but before placing the lock on the door, the purchaser could arrange the tumblers in any way, so that the combination suited his convenience; the key being made with a series of movable bitts, was arranged in a corresponding combination with the tumblers.

In order to make a change in the lock without taking it from the door, each tumbler was so constructed that *in locking the lock* the tumbler could be raised, or drawn out, with the bolt. A series of rings was furnished with the key, corresponding with the thickness of the movable bitts of the key; and any one, or as many more of the bitts could be removed from the key, and rings substituted. These bitts being removed, and the rings taking their place, the corresponding tumblers would not be raised by the turning of the key, and consequently, would be drawn out with the bolt *(becoming, in fact, a portion of the bolt itself)*. Therefore, when a bitt was removed and a ring substituted, so much of the security of the lock was lost as depended on the tumbler that was not raised; consequently, a lock having twelve tumblers being locked with a key with alternate bitts and rings, would evidently become a six tumbler lock; but should a tumbler that was drawn out with the bolt, be raised in the attempt to pick or unlock it, or should any one of the *acting tumblers* be raised too high, the detector would be thrown, and prevent the withdrawing or unlocking of the bolt. This lock was in great repute in the United States, and was placed on the doors of nearly all the principal banking establishments of the country; a large reward was offered by its maker to any one who could pick it; and from its great repute, it consequently called out many rivals.

Mr. Newell, of the firm of Newell and Day, of Broadway, New York, was the most successful competitor, by constructing what he termed his Permutating Lock, which was composed of a series of *first and secondary tumblers, the secondary series being operated upon by the first series.*

Through the secondary series there was passed a screw termed a clamp screw, having a clamp overlapping the tumblers on the inside

of the lock; each tumbler in the series having an elongated slot to allow the screw to pass through. On the back side of the lock was a small round key-hole, in which the head of the screw rested, forming as it were a receptacle for a small secondary key; so that when the large key gave the necessary form to the tumblers, the party took the small key and operated on the clamp screw, clamping and holding together the secondary series, retaining them in the relative heights or distances imparted to them by the large key; the door was then closed, and the bolt projected, and the first series of tumblers fell again to their original position.

The objection to this mode of constructing a lock was, that it required the insertion of the small secondary key; and should the party neglect to release the clamp screw every time he unlocked the lock, the *first series* of tumblers would be *held up by the secondary series*. Consequently, an exact impression of the lengths of the several bits of the key could be obtained *through the key-hole* while the lock was unlocked.

Another and a more convenient method was devised by Mr. Newell. On each of the secondary tumblers he made a series of *notches*, corresponding in distance with the difference in the lengths of the several bitts of the key (see DD in Figs. 1 and 2, Plates 33 and 34); on turning the key each bitt raises its plate or tumbler, so that some one of the notches presents itself in front of the tooth on a dog or lever (HH). As the bolt is projected, the tooth being pressed into the several notches, the secondary series are held in their position by the tooth of this dog or lever, as shown in Fig. 2, thereby doing away with the necessity of the secondary key. In unlocking the lock the tooth is again detached, and the tumblers all fall to their original position and the lock again becomes a blank, as in Fig. 1.

It will be seen that there was no improvement in the actual *safety of the lock against picking*, the only object being to make a lock that could be changed by the party using it, in the most effectual manner.

These improvements were all made prior to the year 1841; so that ten years ago many very valuable additions had been made to the detector and tumbler lock.

In the course of Mr. Newell's studies, he conceived that the lock

of his competitor, Mr. Andrews, might be picked; and the result was the picking of it by a very simple instrument, which is exhibited to the meeting. (See Figs. 8 and 9, Plate 33.)

Mr. Newell immediately afterwards picked his own, with an instrument of a similar construction; so that, in investigating the principle by which he could pick the lock of his rival, he discovered also means by which he picked his own; and his candour in this affair was certainly greatly to his credit, in making it known at once, and not concealing that his lock, as well as *all others based on the tumbler principle, was insecure.*

The question, then, was with him and other makers of locks, in what way should they make a secure lock?

The first step taken was to add a series of *complicated wards to the lock;* but it will be readily seen that what can be reached with a key could be reached by some other instrument; and although it required an instrument of a different form, yet the operation was just as *certain, and fatal* to the security of the lock.

The next step taken, and one which was considered effectual, for a time, was the *notching of the abutting parts* of the first and secondary series of tumblers, or of the stump face and the ends of the tumblers. So that if a pressure was put upon the bolt, the tumblers could not be successively raised by the picking instrument being held fast by these "false notches." This lock baffled the skill of all the country for a time, and was considered perfectly safe, until an ingenious engineer of the name of Pettis informed Messrs. Newell and Day that he believed it was possible to pick their lock. They immediately put their lock to the test, by putting it in a room in the Merchants' Exchange, in Wall-street, New York, offering a reward of 500 dollars, or 100 guineas, to any person who could pick it, allowing them the privilege of *examining the lock as long as they wished, and giving them their own time to make their experiments.*

The result was, that Mr. Pettis accepted the challenge; the lock was picked; and Messrs. Newell and Day lost their 100 guineas. But that was not all; their reputation as locksmiths went also.

The lock in question is now in the United States department of the Great Exhibition, and can be examined by any person; its workmanship is beautiful, and it contains all the points of security hitherto

known and used in tumbler locks: it has sixteen tumblers, a detector, and false notches; yet Mr. Pettis overcame all these obstructions, and picked it fairly.

What was then to be done? The alarm can be readily conceived of every banker, merchant, or broker, that supposed that they had a sure protection in that lock.

The only reasonable conclusion by Mr. Newell was, that security could be obtained, not by *adding difficulties*, because *difficulties could be overcome*, but by constructing a lock so that the *obstructions to the withdrawing of the bolt cannot be ascertained through the key-hole.*

Upon this principle, and with this object in view, the Parautoptic lock, as shown in Plates 33, 34, and 35, was invented by Mr. Newell, retaining all that was deemed good in the locks previously made, and at the same time guarding against all the defects proved by actual experiment. A specimen of this lock is exhibited to the meeting.

Fig. 1 represents the lock unlocked, with the cover or top-plate removed, also the auxiliary-tumbler and the detector-plate are removed.

Fig. 2 shows it locked, with the cover and the detector-plate removed, and the auxiliary-tumbler in its place.

Fig. 3 is the lock with the cover on, showing the detector-plate.

Fig. 4 is a section of the lock taken through the key-hole, showing a transverse section of the tumblers and the bolt.

Fig. 5 is the key; and Fig. 6 an end view of the key, showing the screw by which the separate bitts are fixed in the key. Fig. 7 shows the six bitts of the key detached; and Fig. 8 shows the same key as Fig. 5, but having the bitts arranged in a different succession, thus forming a different key.

AA in Figs. 1, 2, 3, and 4, is the bolt. BB are the *first series* of moveable slides or tumblers, C the tumbler springs, DD the *secondary series* of tumblers, and EE the *third or intermediate series*, which form the connections between the first and secondary series of tumblers. FF are the separating plates between the first series of tumblers; G the springs for lifting the intermediate slides or tumblers, to make them follow the first series when they are lifted by the key. On each of the secondary tumblers DD, is a series of notches, corresponding in distance with the difference in the lengths of the moveable bitts of

the key; and as the key is turned in the lock to lock it, each bitt raises its tumbler, so that some one of these notches presents itself in front of the tooth *h* on the dog or lever HH. As the bolt A is projected, it carries with it the secondary tumblers DD, and presses the tooth *h* into the notches in the tumblers, withdrawing the tongues *d* from between the jaws *ee* of the intermediate tumblers EE, and allowing the first and intermediate tumblers to fall to their original position; whilst the secondary tumblers DD are held in the position given to them by the key, by means of the tooth *h* being pressed into the several notches, as shown in Fig. 2. Should an attempt be made to unlock the bolt with any but the true key, the tongues *d* will abut against the jaws *ee*, preventing the bolt from being withdrawn; and should an attempt be made to ascertain which tumbler binds and requires to be moved, the secondary tumbler DD that takes the pressure, being behind the iron wall IK which is fixed completely across the lock, prevents the possibility of its being reached through the key-hole, and the first tumblers BB are quite detached at the time, thereby making it impossible to ascertain the position of the parts in the inner chamber behind the wall IK. The portion II of this wall is fixed to the back plate of the lock, and the portion KK to the cover.

L is the drill-pin on which the key fits; and MM is a revolving ring or curtain, which turns round with the key, and prevents the possibility of inspecting the interior of the lock through the key-hole; and should this ring be turned to bring the opening upwards, the detector-plate QQ, (see Fig. 3,) is immediately carried over the key-hole S by the motion of the pin P upon the auxiliary-tumbler OO, which is lifted by the revolution of the ring M, thereby effectually closing the opening of the key-hole. As an additional protection the bolt is held from being unlocked by the stud R bearing against the plate Q; also the lever TT holds the bolt when locked until it is released by the tail of the detector-plate Q pressing the pin U. V is a dog holding the bolt on the upper side when locked until it is lifted by the tumblers acting on the pin W. XX are the separating plates between the intermediate tumblers EE; Y and Z are the studs for preserving the parallel motion of the different tumblers.

There are several features in the construction of this lock which are deserving of particular attention. The most novel and extraordinary

is, that the lock changes itself to the key; in whatever form the mov able bitts on the key are changed, the lock answers to that form, withou moving any part of it from the door.

The party purchasing the lock can change it to suit his convenienc If a 6-tumbler lock, to 720; if 7 tumblers, 5,040; if 8, 40,320; if 362,880; if 10, 3,628,800, and if 12, 479,001,600. Therefore it wi be perceived that, by changing the numerical position of the bitts i the key, the lock can be altered, or in fact alters itself to any numbe of new locks, equal to the permutation of the number of bitts on th key. Two extra bitts are supplied with each key, which add ver greatly to the number of changes. As the key turns round, each bi raises its tumbler to a point corresponding with its length, impartin to the first and secondary series the exact form of the key. The secon dary series of tumblers being carried out with the bolt, and the *tootl* on the lever or dog being pressed into the several notches on the fron face of the secondary series, holds them in the position given them b the key, while all the other portions of the lock fall again to thei original position.

Should a pressure be put on the bolt to ascertain the obstructio it will be readily seen that it will be brought to bear on the third o intermediate tumblers. To prevent the possibility of reaching thes there is a wall of metal fixed across the lock, which confines th operator wholly to the key-chamber. By detaching the portion o the tumbler that takes the pressure given to the bolt from the part that can be reached through the key-hole, leaving that portion alway at liberty, the possibility of ascertaining what is wrong is cut off; s that instead, as in the former lock, having only a *first* and *secondar series*, Mr. Newell here introduced a *third or intermediate series* thereby throwing the whole security of the lock into a chamber be yond the wall of metal, which is wholly inaccessible, and forming a it were another lock without a key-hole. These are the principa features of security in Mr. Newell's Parautoptic Lock.

There is another source of insecurity that has still to be provide against: when the first tumblers can be seen through the keyhole, if th underside of them is smoked by inserting any flame, the key will leave a distinct mark upon each tumbler the next time it is used, showing where it began to touch each tumbler in lifting it. This can be seen

by inserting a small hinged mirror into the lock through the key-hole, and the exact length of each bitt of the key measured, from the centre-pin to the point where it touched the particular tumbler, from which a correct copy of the key can be made. (An electric light from a small portable battery has been employed for this purpose, to illumine the interior of the lock.)

The possibility of seeing the tumblers is entirely prevented by surrounding the inside of the key-hole with the ring or revolving curtain; and when this curtain be turned, to bring the opening opposite the tumblers, the key-hole is shut on the outside by the detector tumbler, which tumbler would also detect all attempts at mutilating the interior parts of the lock.

Should the lock be charged with gunpowder, through the key-hole, for the purpose of blowing it from the door, the plug in the back of the key chamber yields to the force, leaving the lock uninjured, whilst the curtain protects the interior of the lock from injury, thereby effectually preventing all known means of opening or forcing the lock.

Mr. Hodge begged to observe, that although he had been drawn into a controversy upon the subject of locks, he had not any personal interest in any lock, nor had ever invented any portion of a lock; and he had taken up the matter purely as a mechanical question, and one, he thought, of very general interest. He had, therefore, brought before the meeting the description of the very ingenious lock of Mr. Newell, and the progress of the invention of the previous American locks; and begged to refer to the report upon the lock by the Mechanics' Institute of Lower Austria, by whom Mr. Newell was presented with a gold medal for the invention.

Mr. Chubb said he considered that he had been treated with unfairness in the trial that had been made of his lock, and complained of the manner in which the lock that had been picked was procured from him.

The Chairman remarked, that the object of the discussion was to ascertain the relative merits of the American lock des-

cribed in the paper that was before the meeting, and the discus-
sion should be confined to the mechanical part of the question.

Mr. Chubb wished to explain that the lock and keys whic Mr. Hobbs had picked, were purchased by Mr. Hobbs, an remained seven days in his possession before the trial took place and any lock might, in a few hours, be made safe to be picked He wished to show that it had not been done in a fair way. H had given in the *Times* newspaper a public challenge to Mr Hobbs to come and pick one of his locks, which he had put upo a door for the purpose, but that had been declined. He denie emphatically that any one could pick, within any reasonable time one of his locks which had not been tampered with.

Mr. Chubb then produced two locks, which he said were of his ordinary make, and offered that they should be examined by the Chairman and Mr. Scott Russell, to ascertain that there wa no unfairness about them, and then put upon a door, and tha Mr. Hobbs might come one day to take the impression of th keyhole, and then come five hours any day during the week, an pick the locks if he could.

Mr. Scott Russell said he thought that was the definit point to be arrived at. He had not been acquainted with th American lock before, and was much struck with its ingenuit and perfection. He certainly considered it to be unpickabl and had a fear that Mr. Chubb's lock was pickable, and he wa glad to hear of the present offer; if Mr. Chubb liked to pu those locks on the table, with the challenge to pick them, an they were not picked, it would be a practical illustration of th excellence of the locks. He suggested that it would be mos eligible for the Council of the Institution to appoint a committe of two or three qualified persons to act as arbitrators in th trial.

The Chairman remarked that the object of the paper bein read at the meeting, was to ascertain the relative merits of th different kinds of locks; but it was not advisable that the Insti

tution should do more in this matter than afford an opportunity for a fair and open discussion, and also for recording the facts of any experimental trial of the different locks. The discussion had now brought them to the point of Mr. Chubb bringing forward his lock, and offering to the American lock-maker an opportunity to try and pick it.

Mr. Hodge said he considered the only fair trial would be, to take one of the locks made for regular sale, not one made on purpose for this trial; and he proposed that the trial should be made with a lock which had lately been purchased from Mr. Chubb's shop, with this object, by an independent party, Messrs. Dew, of Cheapside. This was a legitimate first-rate lock of Mr. Chubb's make, and had been kept sealed up ever since it was purchased, and Mr. Hobbs had never seen it. He proposed that this lock be placed in the hands of a committee, with the approval of both parties, and Mr. Hobbs be allowed an opportunity for picking it.

Mr. Chubb said that in a set trial, he would not be bound to any lock which another person had obtained from him for that purpose.

Mr. Scott Russell suggested that it would be most satisfactory for two or three mechanical men to be appointed a Committee, to settle what should be the terms of the trial, which should be fair to both parties, as a test of the respective locks. That would be an *experimentum crucis*, to bring the question to a settlement.

Mr. Hobbs begged to explain that he had not come over to this country for the purpose of picking locks, but to dispose of his own lock. He was a lock manufacturer; and in the course of explaining the merits of his own lock, it was necessary to show that the lock of another maker was insecure, and he had to prove the assertion practically, by showing that the other lock could be picked. He did not refer to Mr. Chubb's lock in particular, but to the general principles of tumbler locks in this country,

which he maintained were insecure and could be picked; and in his own lock the insecurity that he alleged in other locks was guarded against.

The challenge respecting his own lock, was that a party might take any commercial lock, examine it as much as he pleased, without limit of time, and take the lock to pieces and put it together again, in the presence of competent persons; the lock to be then locked in their presence, and if the party could pick it in any time and after any number of trials, a prize of £1,000 would be given. With regard to the mode of picking the regular tumbler locks, it was a plain mechanical operation with the instrument that had been described.

Mr. Chubb requested that the terms of his challenge might be taken down by the Secretary, who replied that he had done so.

Mr. Geach said he thought as so much was involved in the question, they should give every assistance in setting it right: the greater number of persons who had locks had not the means of knowing whether they were secure or not. A paper had been read to the Institution, in which it was stated that Chubb's and other locks could be picked, not only by Mr. Hobbs, but even by apprentice boys; and therefore he thought the question ought to be set at rest by conclusive experiments, not upon any lock specially made for the purpose, but upon locks which are sold to the public as safe locks. He thought if such experiments were tried before competent persons selected from the Institution, it would be very satisfactory to the public, in order to ascertain, whether the ordinary locks with ordinary facilities for picking were pickable or not.

A Member wished to ask whether Mr. Hobbs did not pick one of Mr. Chubb's locks, at the Exhibition, in seventeen minutes?

Mr. Hensman replied that Mr. Hobbs had done so, and the lock, he believed, was the same as the one laid before the meeting. He examined the lock, and believed it had not been tam-

with in any way; he then locked it, and in seventeen
es Mr. Hobbs picked it fairly in his presence, with the
ption of tool that had been shown to the meeting. He
nt that Mr. Chubb should examine the lock, to see that it
ot been tampered with; he understood that the lock had
urchased by Mr. Hobbs for the purpose, at Mr. Chubb's

Appold remarked that he was also present at the trial,
e confirmed Mr. Hensman's statement. The number of
ck was 142,352.

Hobbs observed, that it had been objected that the lock
ferred to had been in his possession some days before he
it; but if it was in the same state then as when it was
, that did not affect the question; and it was now laid
the meeting. He had picked it at the Exhibition, in the
ce of a party of gentlemen, only for the purpose of show-
e principle upon which tumbler locks could be picked; he
ver taken the tumblers from the lock, nor altered the lock
way, and had merely fitted his instrument to the key-
n the same way that it could be done if the lock were fixed
oor. If any party of gentlemen will purchase one of Mr.
's locks, a fair commercial lock, place it under seal, and
upon a door, he was ready to go and pick it; the lock to
mined previously by the parties and by Mr. Chubb, to
in that it was a fair representation of that principle of

Chairman said he thought the question had better be left
ettled, as had been suggested, by a Committee appointed
parties themselves, independent of the Institution, to
nvolving the Institution in any contest of mechanical skill;
mbers of the council would be glad to assist, and he hoped
ts of the experiments would be laid before a future meeting.
proposed a vote of thanks to Mr. Hodge for his interesting
which was passed.

A paper by Mr. Henry H. Henson, of London, "On Improvements in the Construction of Railway Waggons," was partly read, and the further consideration of it was adjourned to the next meeting. The meeting then terminated.

After the meeting, a party of one hundred and seventy of the Members and their friends dined together at the Freemasons' Tavern, including a number of Foreign Engineers and Jurors of the Exhibition, who had been invited on the occasion by the Members of the Institution, in celebration of the period of the Great Exhibition of the Industry of all Nations. The President of the Institution, Mr. Robert Stephenson, M.P. occupied the chair, and in the course of the evening, the company was addressed by General Poncelet, General Wilson, Colonel Morin, Count Rosen, M. Weidtmann, Mr. James Walker, C.E., Mr. William Keogh, M.P., Mr. Joseph Locke, M.P., Mr. James MacGregor, Mr. J. Scott Russell, Mr. Wyndham Harding, Mr. John Penn, and Mr. Charles Geach, M.P.

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INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

HELD IN BIRMINGHAM, ON 30TH JULY, 1851.

J. E. McCONNELL, ESQ., VICE-PRESIDENT,

IN THE CHAIR.

BIRMINGHAM:

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1851.

PROCEEDINGS.

The General Meeting of the Members was held at the House of the Institution, Newhall Street, Birmingham, on Wednesday, 30th July, 1851, J. E. McConnell, Esq., Vice-President, in the Chair.

The Secretary read the Minutes of the last General Meeting, which were confirmed.

The following paper, by Mr. Henry H. Henson, of London, was then read:—

ON IMPROVEMENTS IN THE CONSTRUCTION OF RAILWAY WAGGONS.

Until very recently, it could scarcely be said that this subject had been fairly entered upon; and it had received but little attention, except from those whose experience had been derived from the construction and working of common road carriages, which, however valuable for the purposes for which they were designed, were based on totally different principles from those required for the Railway traffic of passengers and goods.

Amongst the early contributors to the production of the Railway Waggon, were included the great carriers, their agents, road contractors, farmers, builders, wheelwrights, salesmen, graziers, timber merchants, and others, who differed greatly in their opinions as to what was wanted. Their individual experience, though highly valuable in reference to their respective departments, required, in order to elicit any practical result from this mass of information, to be blended and digested by others more experienced in the practical working of the new system.

One of the greatest evils inflicted upon the Railway Companies,

has been the absence of arrangement or consultation between the officers of the different lines, in order to consider the best construction of the various vehicles intended to be used in the conduct of their traffic. The result has been, that several Companies have built a class of stock to some extent unsuitable to work conjointly the business of their own and other lines. So serious are the evils resulting from this most unfortunate state of things, that it actually at this moment prevents that extent of improvement being carried out of which the system is capable. The consequences of this want of some common plan of action are most expensively felt. The Institution of Mechanical Engineers has proved highly useful in practically investigating railway machinery, and has greatly promoted safety and economy by full discussion and inquiry.

The purpose of this paper is, an attempt to show the progress of construction in Railway Waggons, explaining the gradual changes enforced by circumstances and experience. The writer may here remark, that his attention was first called to this subject by the daily exposure of the merchandise to certain damage, and the constantly recurring loss to the Railway Companies, from the primitive mode in which the conveyance of the valuable traffic was conducted.

The original form of Goods Waggon generally employed on Railways, from the opening of the Liverpool and Manchester line, in 1829, and for many years afterwards, was nothing more than a platform upon wheels, about 10 feet long, with sides varying from four to ten inches high above the floor level. Indeed many of them are still employed, and for certain portions of the traffic, such as minerals, casks, stone blocks, iron pipes, and sundries, they are as well adapted, as they are unfit unprofitable and dangerous if employed in the conveyance of the merchandise generally. The load per waggon was about 2 tons; the weight of the waggon from about 2½ to 3½ tons.

The want of perfection, or unfitness, of the low open Waggon was very early perceived, and the improvement required faintly foreshadowed by the addition of portable sides and ends,

which were merely open crib-rails, dropped in staples at the sides and ends of the Waggon, and secured at the corners by hooks and eyes. To this slight improvement was soon added the worst evil of all, the inflammable and expensive tarpauling, the use of which has involved such costly contingencies. The most striking defect common to the open Waggons, is the facility with which large bales fall from the trucks upon the line, whereby numerous accidents have arisen. In shunting and starting the train, it is clearly impossible that the goods can keep their position on the floor of the Waggon, without the protection of sides and ends.

The crib-rails and tarpaulings are not only very costly, considering they fail to answer the purposes of safety and protection, but their use has entailed great danger and expense. Serious accidents have happened from the negligent way in which the portable sides and ends are suffered to lie about the Railway; the falling of them from the Waggons is an occurrence which has been attended with serious derangement of the traffic. Trouble and expense are also constantly recurring from the great labour of taking down and refixing the crib-rails to the Waggons; and if it be said they are not always removed, then the trouble of loading and unloading must be greatly increased. Neither can the important item of repairs be said to be moderate, if considered, as it should be, in relation to imperfect service, maintenance of crib-rails and tarpaulings—admittedly different articles, but all of them needful to the completion of this most imperfect Waggon; to which may be added claims for damage done to the goods carried by these trucks.

Fig. 1, Plate 36, shows the improved Open Goods Waggon used upon railways at the present time; it has fixed high sides, with doors at the end, and is covered with a tarpauling.

The faults of the tarpauling are so well known to all connected with the practical use attempted to be made of it, that the writer will only observe, that its employment should only to a very limited extent have been permitted in the conduct of the Railway traffic. In a conversation with one of the great carriers, he was

informed that the yearly cost of tarpaulings to the firm was £3,000, and one item of this expenditure arose from the employment of eight men kept for the purpose of repairing the tarpaulings. The writer believes he is perfectly correct in stating, upon the same authority, the use of tarpaulings to have been a charge of 4d. per ton upon the goods.

The tarpaulings were certainly extensively used in the inland navigation of the Canals, to protect the contents of the boats from water, but the same means has been employed, with strange inconsistency, to protect the goods carried by Railway from fire. The costliness of tarpaulings may be inferred from the fact, that to some large Companies the annual expenditure for them is about £12,000, exclusive of all the other expensive contingencies inseparable from their use. In wet weather, the writer has seen as many as three tarpaulings used in covering the contents of a single Waggon, and even these have failed to keep dry the merchandise. This arises from the great number of small holes which are daily made in them, from some sharp point or angle of a package cutting them through. So uncertain is the probable duration of a tarpauling, that a new one is sometimes spoiled the first day of its employment; each tarpauling costing from £4 to £6.

It is evident that an open truck is a box without a lid, whether it be made of crib-rails or deal-board sides and ends. Over this a tarpauling is thrown by three or four men, who attempt to secure it, by pieces of rope provided for the purpose, to the hooks or rings attached to the Waggon, but it often happens that the trucks are not filled to a level with the top side of the Waggon; the consequence is, that when heavy rains fall, the weight of the water collected on the top of the tarpauling is so great, as to invert it in the centre, making a pond or dished cistern, of about nine inches deep, or more, containing many gallons of water.

The Goods Manager of one of the great lines informed the writer, that in the wet season he has employed as many as twenty men to throw off the water collected on the tops of the tarpaulings, and tighten them on the road, at one station only; but that on their arrival at London they were again in the same state: this was

the tarpaulings were sound. In those cases where they not water-tight, the damage done was serious; tea, sugar, e, silks, and indeed all other goods were more or less ged, entailing complaints from the public, and much loss to ompanies.

ose princely merchants, the East-India Company, have n much more tact and prudence, in the employment of a covered portable warehouse on wheels, perfectly secure any contingency whatever; to have employed an open cart arpauling, for the removal of the treasures of the East from ocks to their warehouses, would have been a parallel to the Railway Waggon, and as costly.

e various drawings will convey some idea of the progressive e and date of the changes in construction of Railway Waggon . The success and extent of these improvements may be red from the fact that, ten years since, the stock of one great vay Company was only one fifth of its present number, and money receipts about one sixth, yet the annual cost for tenance is now not double the amount it was at the period red to.

e attention of the writer was forcibly called to the immense arising from the destruction of property—occurring whenever ccident took place—not only from damage done to the goods e open Waggons broken up, but also much more from goods wn out of the same, when off the line; the ordinary open gon being no better than a box or basket without a cover, which is ejected the whole of its contents when the gon is turned over; and this has sometimes been upon ails—into a field—a ditch—down an embankment—or into al.

ese evils were often the subject of remark, and finding that ne attempted to improve the system, the writer determined ake an effort, which has resulted in the New Covered Goods gon, shown in Fig. 2, Plate 36, and of which a model is e the meeting. This subject is brought forward for the ose of calling attention to the remarkable contrast which has practically found by experience to result from the use of the

New Covered Waggon, or Transit Warehouse, as compared with the open waggon.

Accidents to trains containing the New Covered Waggons have happened; some of them have been thrown to the bottom of steep embankments, and others forty feet from the rails, into a field, and in fact exposed to all the violence of collisions taking place with trains consisting of seventy Waggons, travelling from twenty to thirty miles an hour, and loaded on an average with 3½ tons each, the gross weight in motion being about 490 tons; and in all cases, and under the most difficult circumstances, the contents of the Covered Waggons have been preserved, in most instances, from any damage whatever, while the waggons themselves, from the peculiarity of their construction, have sustained so little damage as to have excited particular notice. A case recently occurred of two of these being thrown off the rails, while the train was at full speed, containing 4½ tons of goods each, which were not at all damaged, neither was the square of the waggons found to have been broken.

In the year 1830, the speed of passenger trains was under twenty miles per hour, but at this period the speed of goods trains reaches from twenty to thirty miles an hour, with a degree of safety not at all second to the passenger trains: therefore, the sound construction formerly necessary for passenger carriages became fully needed by the present requirements of the traffic for the goods Waggons.

The construction of the New Covered Goods Waggon is adapted to meet this demand. By a well-considered and scientific employment of wood and iron, perfect rigidity has been obtained in all parts of the superstructure of the Waggon, which has the effect of permitting the utmost freedom in the mechanical parts intended to move, and thereby greatly to facilitate its following the engine. The New Covered Waggon, while it actually costs less, first cost excepted, performs the important service of running more miles, and earning a larger sum of money, free from all claims for damage, than any other Waggon in use. It is in more favour with the carriers and the public, and is consequently more employed; and it is acknowledged to be so little affected in

ring repair as to have excited attention. It was remarked a lays since, that the Covered Waggons were rarely out of ; in fact, only through accidents, and repairs caused thereby, e and wheel-turning being the chief charges against them.

will be observed in the section shown in Fig. 4, Plate 37, he side door-posts of the Waggon, the opening for the admission ods, the slide, roof, ribs, waterway, and door-beads, are ples of a combination of wood and iron of much value. loors, slide, and waterways, although in continual use for ears, have not cost two shillings each for repairs; neither single door-post been broken, or in any way damaged.

important feature in the New Covered Waggon is, having ned a perfectly even and smooth interior of the sides and of the body, or loading space, which is nearly 600 cubic being almost double that of the ordinary open goods truck. practical value of this improved surface has most effectually ited the public, the carriers, and the Companies; whereby use of great complaint, expense, and trouble, has been ved. The cases of damage done to bales of goods, by ng against the uneven surfaces of the bolts and rivet-heads e open Waggons, has been reduced to one in a thousand cases ose constantly occurring before. The entire build of the gon is so contrived, that when once closed it cannot be ed or taken to pieces, even by the workman who has con-ted it, without first obtaining access to the interior, the e of the superstructure being fastened from the inside; a and bolt of great simplicity are secured on the same prin- One man can open and securely close the New Waggon, several men are required to put the tarpauling on the open gon.

e inflammable nature of the coverings used for Open Waggons ly increases the risk of fire, from cinders falling upon them the Engine, and which would happen daily but for the nate circumstance of the wind seldom blowing in a direct with the progress of the train. But for this mere accident, taking fire would be daily occurrences.

The Covered Waggon also affords the most remarkable protection to other Waggons from being ignited by their proximity to any that may be on fire in the train. Instances have happened on several lines of Railway, property where in Open Waggons, as well as the trucks themselves, have been destroyed. The New Covered Waggon, if in a train of ordinary Waggons on fire, will effectually cut off the progress of the flames from being extended to the next tarpauling, and consequently to the open Waggon and its contents. Several instances of the New Waggons rendering this service have arisen. One of them contained some thousand pounds' worth of silk, and in the words of the official report, the contents were not damaged, while the Waggon itself was merely charred, and the paint blistered at the end next the fire, which was raging while the train was drawn into the nearest station. In fact, fire occurring in open Waggons spreads rapidly; the flames being very forcibly driven backwards by the speed of the train, will fire all the Waggons behind, if covered with tarpaulings, or open, but they are effectually stopped by the Covered Waggon checking the progress of the flame back.

The liability to fire is only one of the many objections to the tarpauling covering; it is very liable to be blown about, and sometimes off, exposing the contents of the Waggon to every contingency.

The perfect security now obtained in the transit of the goods in the Covered Waggons has caused the ordinary insurance of one pound per ton for silk to be discontinued, as also an allowance formerly made to the men for extra care of the goods previously conveyed in open Waggons. The object of the writer has been, to avoid every known defect of the open Waggons, and gradually, as far as practicable, to remove the immediate causes of damage to goods, loss of waggon service, and to reduce repairs as nearly as possible to grease and wheels, and so to improve the construction generally, as to adapt it to the varied, but well-defined requirements of the Railway system. The absence of all claim for damage done to property, carried in the New Waggon, is a fact that proves some success has attended these efforts.

urther proof of the value of the Covered Waggon may be
red from the fact, that the carriers consider their work to
lf done, when once the goods are deposited in the Improved
Covered Waggon, as compared with the serious respon-
ty of sending the goods in an open Waggon. The carriers
d to the writer that great anxiety is felt until the time has
d for the arrival of the open Waggon at its destination, and
elivery of one post; and it is only on the non-arrival of
laint at the period referred to, that the carriers begin to feel
e from any claim for damage. The Corresponding Clerk of
arge establishment also reports that he is at a loss to name
mount for the unmistakeable saving effected in corres-
ence, since the Covered Waggons were first introduced; and
especially as the traffic has increased to an extent not
pated by the most sanguine. The goods deposited in a
red Waggon invariably arrive in precisely the same state as
loaded, free from wet, &c. Some thousands of letters less
come to hand in reference to goods lost and damaged by
yance in open Waggons.

en with what used to be considered the *ne plus ultra* of the
Waggon plan, (Fig. 1, Plate 36,) with that great step in
ovement—permanent wood sides and ends—little more
ity is effected than by crib-rails. This plan can hardly be
o have been subjected to the rule of science at all; it merely
sts of certain parts of wood and iron, most unskilfully
rtioned to construct a Railway Waggon, the sides and ends
ng the superstructure being boards merely laid horizontally
to edge, and the standards bolted across the face of the
s, at right angles; leaving all free to work, like so many
lel joints. The effect of this mode of building is, that the
of the parts soon become loose, and, quite as much as the
, accelerate the destruction of the Waggon.

other cause of serious expense, attached almost exclusively
Open Waggons, is the great danger and outlay incurred by
efective state of the floors, which are found to decay rapidly,
onsequence of continual exposure to the different effects of

summer and winter. No attention had been directed to the importance of constructing Waggon stock to remove this serious defect, until the writer gave it his consideration. He has seen hundreds of the open goods and cattle waggons standing, in winter, with two inches depth of manure and water covering the entire area of the floor, in which holes have afterwards been made to let out the water. One of the greatest practical evils resulting from rotten floors is, the great facility with which the legs of the cattle have slipped through and been broken. The trains have in some instances been thrown from the line, causing much delay and expense. In one or two cases, the beast fell completely through the bottom of the Waggon upon the line, whereby the traffic was interrupted, and much damage done. Open merchandise Waggons would be the source of many more accidents and greater expense, but for the vigilance of experienced and attentive local examiners of the trains, at the stations on the road. The constant expense caused by the exposure of the Open Waggons to the deteriorating influence of the weather, whether in or out of use, is most serious in amount, as there are several millions' worth of waggon property undergoing depreciation from this cause, for which the Companies have to pay a tax equal in amount to that for the employment of the work.

The result of many years' experience has shown that doors at the end of a waggon are a source of great expense for maintenance, as the ends are subjected to by far the greatest portion of the work, from the violent strains in starting and stopping; and the end doors also cause much inconvenience in working at the stations. The adoption of side-doors was, however, considered objectionable, because the sides of the waggon were then cut completely in two, and rendered weak; but this objection has been got over in the New Roofed Waggon, in which the sides are fully as strong as the rest. The side sliding doors of the New Waggon are always free to move, as well as the moveable portion of the roof, by which valuable provision, the crane chain can deposit or remove a bale of goods, however heavy, from any part of the interior of the Waggon.

(See Cross Section, Fig. 4, Plate 37.) Indeed, such is the ease with which the operations of loading and unloading can be performed, that the carriers report that the goods almost tumble in and out of the Covered Waggon, when the steam crane is used: at once removing all doubt, if any were entertained, about the great saving of labour, and absence of all inconvenience, attending the use of the New Waggon. In the words of the carriers' report, "no one can properly estimate the saving effected in property and time by the employment of the Covered Waggon."

In addition to the serious disadvantages of the old open plan of Waggons, with which property to a large amount is either stolen, burnt, or damaged by water and other means, there is yet another remarkable circumstance, that has not been adverted to. Some Waggons contain meat instead of merchandise, and then they not unfrequently become a travelling cooking apparatus, in which cargoes of whole sheep and pigs are roasted, but, what is much more unsatisfactory, spoiled also. The New Waggon is not only proof against fire happening to its contents from external causes, but is almost so in reference to its own construction. One of the plans generally adopted, is an entire outside skeleton of wood framing, well secured in all its parts by suitable ironwork, the inside of which is lined with sheet-iron plates, of No. 16 gauge, which are fixed by screws to the wood scantling. The under side of each plate is bedded upon strips of felt, laid upon the inside of the wood standards, three inches wide. The plates form a flush butt joint with each other, having a surface bearing of 1¼ in. against the framing of the body, thereby securing a perfectly even and smooth surface of iron over the entire area of the loading space. This evenness secures the packages from damage by chafing, and effects great durability and rigidity in the superstructure of the Waggon, and consequently great reduction of cost for repair.

Fig. 7 explains the plan of constructing the roofs, which are also made of No. 16 gauge sheet iron, laid upon bent ash ribs, 3×1¾ inches, on the top surface of which are placed strips of tarred felt, 2¾ inches wide, upon which each sheet of iron has a surface

bearing of 1¼ inch, and is secured to the rib by screws. It should be observed, that the plates intended to form the roof are so laid as to leave a space of ¼ inch between the edges of each, for the purpose of allowing a screw to pass between the edge of each plate. This space, and the upper surface of each sheet of iron, are, in like manner to the under side, covered by a strip of felt, 2½ inches wide, upon which is laid transversely a piece of hoop iron of the same width, and this is made to cover the two rows of screws by which the iron roof-plates are made fast to the wood ribs, and is itself secured by a single row of screws passing between the edges of the plates forming the roof. The cost for maintenance of roofs so constructed is merely nominal, no case of repair having yet happened (accidents excepted) in five years, while the certain cost of tarpaulings for 500 Waggons during that period, would not be less than £7,500.

The section of the slide roof and waterways, shown in Fig. 6, Plate 37, will explain the construction of that important part of the New Covered Waggon. It will be seen that the moveable portion of the roof runs upon rollers of chilled cast iron, accurately turned, and revolving on a steel axle, to prevent wear. The waterway and roller path is partly covered with a flat strip of iron, on which the rollers freely work, and move the slide roof. The plate of iron, A, answers the purpose of strengthening the wood rib, B, and effectually prevents any water getting into the interior of the waggon; its surface is also useful for the crane chain to work against, and thereby protects the wood from injury. The whole of the space for the admission of goods is in like manner faced with iron, which renders repair of this part of the Waggon most trifling. By this mode of construction, the dimensions of the door opening and its respective working parts are accurately preserved; consequently, the doors and slide are always found to move easily. The slide, C, is most effectually prevented from removal for improper purposes, by the external rib, D, and the iron top plate, secured by a bolt, E, and nut, on the inside of the sheet-iron roofing.

Fig. 5 shows a full-sized section of the doors, side waterway, and roller path in which they work; and of the inside casing by

which, when out of use, the doors are protected. It also shows the level of the floor-line and door-post, faced with bevelled iron plate, forming also a snap bolt and nut. All these parts of the Waggon have so perfectly answered the purpose for which they were designed, that after six years' use, the writer is not aware of any alteration that can be made with advantage to the plan.

Fig. 3, Plate 36, represents a Covered Waggon of similar construction to that which has been explained above, with this difference, that the doors on both sides, and the corresponding part of roof, are framed together, and move longitudinally either to the right or left, as may be desired.

Plate 38 represents sections of four other plans of moving roofs: Fig. 8 being suitable for a goods Waggon where sliding doors on each side are requisite, and is formed of two slides, A A, moving transversely upon the Waggon, one above the other. This plan of Waggon is in all other respects constructed in the same manner as the one shown in Fig. 2.

Fig. 9 is a section showing a roof, with the slide, A, running longitudinally in grooves upon the top of the Waggon, and applicable to such as have doors at the end.

Fig. 10 is on the same principle, with the exception that the slide, A, moves upon an iron rod, B, secured on each side of the roof, the moving portion of which is kept in its place by eye-bolts, through which the rods pass.

Fig. 11 is a part elevation of another plan of roof, by which the sides, A A, move longitudinally to the right and left. This arrangement is suited to Waggons that are required to have folding doors on each side.

All of these plans have been for some time practically in use, with advantage.

There are several modifications of the plan of building these improved Waggons, but the one shown in Fig 2, and another in which deal boards are used, instead of the iron plates, to form the body, as before described, are those generally adopted. The roof is in all cases formed of sheet-iron, painted.

The subject of dead weight, as compared with the load carried is of importance.

The original Waggons weighed from 2 to 2¾ tons; load, about the same.

The present Open Waggons, Fig. 1, weigh 3½ tons: load, 4½ tons; being 1 ton in favour of paying weight.

The New Covered Waggons, Fig. 2, weigh 3½ to 5 tons. A few only, with iron floors, heavy axle-boxes and wheels, weigh 5 tons; the general class weigh 4 tons, carrying 6 to 8 tons.

The exact weight of the present build would be 3½ tons: load, 6½ tons. Paying weight, as compared with dead weight, 3 tons gained. The general class of low-sided Waggons weigh from 2½ to 4 tons, carrying 2½ to 4½ tons. The general class of high-sided Waggons weigh from 2¾ tons to 4 tons 2 cwt.: load, 3½ to 4½ tons.

In concluding this paper, the writer will refer to a few of the items in which a saving has been permanently effected. He more particularly wishes to remark, that in the removal, by the Covered Waggons, of many old and expensive sources of repair, common to the open Waggon, he certainly has not introduced any new ones in connection with the improved plan of Waggon, the construction of which will so much lessen repair, that the reduced expenditure, as compared with the ordinary open Waggon, will in time provide a fund sufficient to reproduce the Waggon; saving the necessity of laying by money to meet any loss arising from depreciation.

The cost of maintenance of the open Waggon stock varies from 7 to 10 per cent. on the first cost of the same. The repairs of the Improved Waggon do not exceed 4 per cent. on the prime cost. Difference in favour of the New Covered Waggon, about one half.

The cost for tarpaulings to cover the open Waggon is reported in some instances to be so moderate, and in others so high, as to leave some doubt upon the subject. That it is most serious, all are aware. The writer, who has paid some attention to this subject, is prepared to prove that the charge cannot be less than 6 per cent. on the cost of the open Waggon. The whole of the charge for tarpaulings is saved by, and is therefore in favour of,

the Covered Waggon. The annual cost for tarpaulings, to one large Company alone, is £12,000.

The open Waggons are further chargeable with most serious items arising from damage done to goods by water, loss by pilferage—in some years hundreds, and as often thousands of pounds; also destruction of property by fire, to such an amount, that it is serious even to a Railway Company; and claims for compensation, arising from causes too numerous to be more than adverted to.

The use of the Covered Waggon may be said to be free from this catalogue of charges; to which may be fairly added the fact, that while the improved Waggon costs less, as shown in every way, it actually gains a larger sum of money than the open Waggon, by being more constantly in condition to work, and secures its earnings free from the deductions referred to.

The cost of these Improved Covered Waggons does not now exceed the price formerly paid for the old open Waggons.

Mr. Henson exhibited a complete working model of his improved covered waggon; he said it possessed as great a capacity for loading as the ordinary goods waggons, and was quite as strong, if not stronger.

Mr. Slate inquired, how often the new waggon could be loaded, in regular traffic, with goods to the amount of seven or eight tons; and what description of goods was intended to be carried by it; and what weight of light or damageable goods it would hold?

Mr. Henson replied, that the waggon would take to the amount of from five to seven tons of sugar, silks, &c., and other damageable goods. It was calculated for the convey-ance of Manchester goods, which were generally heavy; and

these waggons were found by the carriers particularly serviceable in carrying, with perfect security, these descriptions of damageable goods. Sheet and hoop iron also would load them to seven tons; and these goods required substantial covering, to protect them from rust and other injuries; and serious loss was sometimes experienced from the damage caused to them by exposure to the weather in the ordinary open waggons.

Mr. SLATE observed, that in Mr. Henson's waggon the reduction of the tare was certainly very considerable; it appeared he had produced a vehicle which, for every ton of its own weight, would carry double the weight of goods. This was a great step in the right direction, and he hoped the waggon might be further enlarged and improved—even to double its size—that expenses might be saved, and a reduction in the carriage of heavy goods be effected.

Mr. HENSON replied, that the great objection to any extension of the length of the waggons, was the manner in which they were now confined by the station buildings, the approaches to the warehouses, and the turn-tables. Great alterations would be required at the stations, along the whole line of railway, before any enlargement of the present size of waggons could take place.

Mr. W. SMITH said, it was clear that the waggon possessed every facility for loading all kinds of goods; and it had been shown, in various ways, that the ordinary open waggons and tarpaulings were very imperfect and expensive. He saw that certain parts of the new waggon were made of corrugated iron; and he wished to inquire where the extra strength and saving in weight were obtained; and why the framing and the platform were not also made of iron, instead of wood?

Mr. HENSON explained, that he considered the combination of wood and iron that he had adopted was decidedly the best. In his opinion, an entire iron waggon would not only be heavier, but it would be weaker, while, at the same time, it would be considerably more expensive, and more difficult to

r. The wood prevented the iron from bending, and the prevented the wood from breaking; and by these means a increase of strength was obtained.

ie CHAIRMAN remarked, that this question of construction been discussed upon a former occasion, after a paper read r. Adams; and the relative merits and strength of iron and , as used separately or combinedly in the construction of ay carriages, was an important subject for consideration: d been recommended to make the under frame of iron.

r. W. SMITH suggested, that the waggons should have sides and ends entirely, as well as iron tops, if the object to protect the goods against the effects of fire, as protec- was quite as necessary in that part of the carriage, when a was on fire, as it was on the roof.

ie CHAIRMAN observed, that he could bear testimony to new waggon being an effective security against fire. In own experience, he had known it operate, when placed een two of the old waggons, as a complete check against rogress of fire in a goods train on the railway.

r. SLATE, referring to the model of the new waggon, ed the great additional strength which the roof, from its ruction, gave to the body of the waggon, as compared to pen waggon. The frame acted as diagonal bracing; while roof, like the deck of a ship, strengthened the general ture of the vehicle.

r. COWPER observed, that the roof of the waggon made whole body, as regarded strength, into a complete girder, e full depth of the waggon.

r. ADAMS quite agreed with Mr. Henson, with regard to the tion to iron for the upper framing; there would be great ulty in riveting corrugated iron to iron framing, and such cess would necessarily lead to considerable expense; but it comparatively easy to fix the corrugated iron by screws to framing. He was of opinion, however, that iron was r for the under framing than wood. He considered

that the waggon, as constructed, was very safe from fire; and if, with a dead-weight of only 3½ tons, it could carry 6 or 7 tons of goods, it was most unquestionably a very efficient vehicle.

The CHAIRMAN said, the protection against fire went far to show the superiority of Mr. Henson's waggon; and when they considered the great losses to which Railway Companies were subjected, by damage done to goods entrusted to them for conveyance, it was evident that great advantages were derivable from efficient protection, by having the waggons completely closed, and as nearly as possible air-tight. It would also be a great saving to Railway Companies, in reducing the proportion of the dead-weight of the waggons, as compared to the paying weight carried; and in addition to the protection from injury and loss, the expense of goods conveyance would be considerably reduced, and the means of carriage increased. He proposed a vote of thanks to Mr. Henson, for his paper, which was passed.

The following paper, by Mr. C. W. SIEMENS, of Birmingham, was then read:—

ON A NEW REGENERATIVE CONDENSER FOR HIGH-PRESSURE AND LOW-PRESSURE STEAM ENGINES.

THE Condenser of a Steam Engine has for its object the complete discharge of steam from within the working cylinder, after it has served to propel the piston. This is effected by conducting the expended steam into a closed chamber, containing an extended surface, of comparatively cool substance, which absorbs the latent heat of the steam, and thereby reduces it to its liquid state. Cold water is generally employed for this purpose, which is either brought into immediate contact with the steam, as is the case in Watt's Injection Condenser, or through the medium of metallic walls, as in the Surface Condenser by Hornblower, improved upon by Hall and others.

The more or less perfect condensation of the steam depends—

1st.—On the absence of air from the Condenser.

2nd.—On the temperature at which condensation takes place.

The appended Table shows the elastic force of steam in vapour, various temperatures. It will be observed that, in order to oduce a perfect vacuum, the water should leave the Condenser about 32° Fah., or be introduced in the form of ice. Connsing water, however, is generally obtained at the temperature about 60° Fah., and it leaves the Condenser at about 110° Fah., ich latter temperature implies a remaining atmosphere of pour equal to 2.5 inches of mercury, or in other words a vacuum 27·5 inches below the atmospheric pressure at 30 inches. If ess quantity of condensing water be used, it will be raised to a oportionately higher temperature, and a less perfect condensan be effected. At 212° Fah., the pressure of the uncondensed pour would be equal to that of the atmosphere, and the object the Condenser would be entirely frustrated.

In all cases where an abundant supply of condensing water nnot be obtained, or where the heat of the steam employed by e Engine is reclaimed for other purposes, Steam Engines e worked without a Condensing Apparatus (or at high pressure) the sacrifice of an effective pressure nearly equal to that of the mosphere upon the working piston. The *Regenerative Condenser* e subject of the present paper) redeems the Engine from this ste of heat in the one case, and loss of mechanical effect in e other case, being possessed of the peculiar property of turning the condensing and condensed water at the initial mperature of the steam previous to its discharge from the orking cylinder, (commonly speaking, at 212° Fah.,) effecting vertheless an efficient vacuum.

Fig. 1, Plate 39, shows a sectional elevation of the Regenerative ondenser, as applied to a 10HP high-pressure Engine. consists of an upright rectangular trunk of cast iron, A, the wer end of which, B, is cylindrical, and contains a working ston. The trunk is filled with metallic plates, which are aced upright, and parallel to each other, with intervening aces of not less than $\frac{1}{16}$th of an inch in breadth. The upper tremity of the Condenser communicates on one side, E, to the haust-port of the Engine; and on the other, to the hot-well, F, rough a valve, G. A stop, H, prevents the opening of the valve

beyond a certain distance, in order that it may re-shut more instantaneously. The metallic plates D, are fastened together by five or more thin bolts, with small washers between the adjacent plates, which keep them the required distance apart. They can easily be removed from the Condenser, for the purpose of cleaning, by taking off the cover, I, and drawing out the whole of the plates.

An injection pipe, K, enters the Condenser immediately below the plates; it is provided with a small air-vessel, L, and a regulating cock.

The action of the Condenser is as follows:—

Motion is given to its working piston by the Engine, causing it to accomplish two strokes for every one of the Engine.

At the moment when the exhaust-port of the Engine opens, the plates, D, are completely immersed in water, a small portion of which has entered the passage above the plates at A, and is, together with the air present, carried off by the rush of steam through the valve, G, into the hot-well, where the water remains, while the excess of steam proceeds into the atmosphere. An instant after the partial discharge of the steam cylinder has commenced, the water recedes between the plates, D, and exposes them gradually to the steam, which condenses on them in the manner following. The upper edges of the plates, emerging first from the receding water, are enveloped in steam of atmospheric pressure, and in condensing a portion thereof, they become rapidly heated to nearly the temperature of the steam, or about 210° Fah. The partial condensation diminishes the density and temperature of the remaining steam, which requires additional and cooler surfaces for its further condensation. This is provided for by the continual emerging of additional portions of the metallic surfaces from the water. By the time the water-level leaves the plates, the far greater portion of the steam is condensed. The condensation of the remaining portion of steam could not so readily be accomplished by means of metallic surfaces, but the piston, C, continuing to descend, puts it into immediate contact with the jet of cold water from the pipe, K, which completes the vacuum in the manner of a common Injection Con-

ser. The air-vessel, L, connected with the injection pipe, has effect of accumulating the injection water, at the time when water has ascended between the plates, and of forcing it into Condenser with increased intensity, at the time when it is ired to complete the vacuum.

lthough the action of this Condenser is strictly consecutive, it does not check the continuous flow of steam from the nder, and it completes the vacuum when the working piston e Engine has only accomplished one tenth part of its stroke. n the engine-crank and the crank driving the Condenser are he top centre at the same moment, but the latter completes revolution in the time of half a revolution of the Engine; sequently, when the engine-piston has passed only one-tenth the whole stroke, the condenser-crank will have travelled ugh nearly half its stroke, when the whole process of con- sation will have been completed. The principal part of the nt heat of the steam is stored up in the plates, the upper remities of which are heated to 210° Fah., and the lower, to ut 150° Fah.

The water, in re-ascending between the plates during the last th part of the stroke, absorbs heat therefrom in a similar cessive manner, passing first the coolest, and by degrees hottest portions of their surfaces, and issues finally into upper steam passage, at a temperature approaching the ling point, at which moment a fresh discharge of steam takes ce, which carries it off into the hot-well, as above described, l raises its temperature fully to the boiling point.

Fig, 3, Plate 40, represents an actual indicator diagram, show- the time occupied in completing the vacuum; but it will be erved, that the loss of time and power may be decreased by reasing the capacity of the displacing cylinder; but, as it is, s loss does not amount to one seventh part of an uniform uum, an equivalent for which is obtained in the saving of the ver hitherto absorbed by the air-pump; for it will be observed, t the displacing piston works between two vacuums, and refore meets with no resisting load.

Various modes have been provided to give motion to the dis-

placing cylinder, among which a knee motion, worked directly from the beam or cross-head of the engine, is generally found the most convenient, as shown at M M in Fig. 1.

The quantity of condensing water required with this Condenser to condense one pound of steam, of atmospheric pressure—taking the initial temperature of condensing water at 60° Fah., the final temperature at 210° Fah., the latent heat of steam of 212° Fah. at 960 units—is

$$\frac{960}{210-60} = 6 \cdot 6 \text{ lbs.}$$

of water to condense 1 lb. of steam.

The common Injection Condenser (supposing the condensing and condensed water to issue at 110° Fah.) requires

$$\frac{960+(212-110)}{110-60} = 21 \cdot 2 \text{ lbs.}$$

in place of the 6.6 lbs. which the Regenerative Condenser requires. In the case of a locomotive, or other high-pressure Engines, where the steam is released from the cylinder at a pressure of, say 30 lbs. above the pressure of the atmosphere, two thirds would be allowed to escape uncondensed, and a vacuum be obtained with only $\frac{6\dot{6}}{3} = 2.2$ lbs. of condensing water for every 1 lb. of steam passed through the cylinder.

The small quantity of condensing water required, renders the proposed Condenser applicable to Engines in nearly every locality; and pains have been taken to render the apparatus itself equally light and compact. The advantages resulting from its application to high-pressure Engines are as follows:—

1. Additional effective power, gained on account of the vacuum.

Fig. 3, illustrates this gain, which (supposing the average steam pressure to be = 40 lbs. above the atmosphere, and vacuum within the cylinder = 10 lbs.) amounts to 20 per cent, irrespective of expansion. If both the steam pressure and the duty on the Engine remain unchanged after the Condenser is applied, it is evident that the steam may be worked expansively to a large extent, without diminishing the absolute driving power of the Engine.

2. Heat saved in generating the steam, by the use of *boiling-t feed water;* and the remaining portion of hot water may be lvantageously used for heating buildings, dyeing, &c.

High-pressure Engines are frequently provided with heating paratus for the feed water, which heats it on the average to out the temperature of the condensing water from low-presre Engines, or 110° Fah. The proposed Condenser heats it to 0° Fah., which constitutes a saving of $\frac{210-110}{960}$ = about 10 r cent.

When such heating apparatus is not provided, the saving nounts to $\frac{210-60}{960}$ = about 15 per cent.

3. The steam which is not condensed may be used to cause draught in the chimney, or for other purposes.

4. The displacing cylinder, unlike the air-pump of the Injecn Condenser, abstracts no motive power from the Engine.

5. The Condenser may be started and stopped at any time, by rning the supply of injection water either on or off. If turned , it at once forms the vacuum, without involving the necessity blowing through; and if turned off, it allows the Engine to oceed in the same manner as though no Condenser had been plied.

6. The air contained in the Condenser is, at the commenceent of each stroke, *bodily expelled*, which is of great advantage the formation of a good vacuum, instead of the ordinary airmp removing only a portion of the air at each stroke, and consently leaving a portion always in the Condenser.

7. The Regenerative Condenser is more compact, and even ss expensive than the ordinary Injection Condenser, being less an one quarter of the size, and having only one valve instead three.

Its proportionate dimensions are as follow:—Area of platehamber, three times the area of exhaust-pipe; length of plates, ne quarter to one third part of length of stroke of engine; thickess of plates, $\frac{1}{32}$nd part of this length. Spaces between the lates, the same, but never less than $\frac{1}{16}$th of an inch, it having

been found that the alternate rush of water and condensing steam prevents the settlement of grease and earthy matter between the plates, if they are not less than $\frac{1}{16}$th of an inch apart. Capacity of displacing cylinder, equal to one and a half times the capacity of the plate-chamber. The total capacity of the Condenser is only equal to about the tenth part of the capacity of the working cylinder. In applying the Regenerative Condenser to existing high-pressure Engines, a saving of fuel of from 30 to 35 per cent. has been effected, or an increase of power to that amount with the same expenditure of fuel as theretofore. This saving may however be still considerably augmented, if advantage be taken of the increased effective pressure to work the engine expansively. This may in most cases be easily effected, by merely adding to the lap of the slide valve, and increasing the lead of the eccentric proportionately, whereby the additional advantage of a more early discharge of the steam is obtained.

The advantages attending the application of the Regenerative Condenser to stationary Engines being practically proved, the author is desirous to extend the same also to that important class, the Locomotive Engine. In inviting the attention of Railway Engineers to this inquiry, he is prepared for practical objections being raised, on account of the great rapidity of motion, the necessity for the greatest possible simplicity and lightness, the deficiency of condensing water, &c.; but he thinks that the Condenser under consideration is peculiarly well adapted to meet these objections.

Its peculiarities in this respect are:—That it may be accommodated to any speed of piston, by reducing the length and increasing the breadth of plates, thus reducing the velocity of the displacing piston proportionately.

Its dimensions are proportionate to the capacity of cylinder only, and not (like other Condensers) to the horse-power of the Engine.

The total weight of a pair of Condensers, as applied to a locomotive Engine with cylinders of 13 inches diameter and 20 inches stroke, is about $3\frac{1}{2}$ cwt.

The power of the blast remains nearly undiminished.

The Condenser requires no attention in working the Engine, d in case it should fail to act, from any accidental cause, the gine will continue to work high-pressure as usual; moreover, does not interfere with the working parts of the Engine.

The advantages which would result from a vacuum in the inder of a Locomotive Engine, have been ably set forth by . Edward Woods, in his "Observations on the Consumption of el and Evaporation of Water in Locomotive and other Steam gines."—The present paper may therefore be limited to the ans proposed for that purpose.

The two Condensers are cast in one piece, and placed imme- tely in front of the cylinders of the Engine. Each of them sely resembles the Condensers above described; only the gth of the plates, and the stroke of the displacing pistons, are ch reduced in proportion to the steam cylinder, in order that velocity of the water between the plates may not exceed tain limits.

The two displacing pistons are connected to opposite ends of hort vibrating beam, which receives its motion from the Engine. In addition to the exhaust valves leading into the hot-well, se Condensers are provided with a second set of discharge ves, of a somewhat peculiar construction, which, with very ited motion, combine the advantage of opening a perfectly ar passage for the exhaust steam of the Engine into the mney, where its remaining expansive force is required to pro- ce draught. This valve consists of a longitudinal rectangular t, in the upper wall of the steam passage which leads from the linder to the Condenser.—At the ends of the slots are trian- ar pieces, which support the sides of two longitudinal lips ich cover the aperture, except at such times when a superior ssure from within forces them open. The extent of their tion is limited by dead stops.

The escape of steam, together with the hot water, into the hot- ll, is regulated by a blow-off valve from the latter into the nosphere; by this means a pressure above that of the atmos- ere is obtained in the hot-well, which acts favourably in forcing e boiling-hot condensing water into the feed pump of the boiler.

It has been stated above, that the ordinary supply of feed wate
is of itself not quite half sufficient to maintain a vacuum withi
the Condenser, and an additional supply of water must be pro
vided for. Considering, however, the smallness of the excess o
condensing water, especially if the diameters of the workin
cylinders are reduced in proportion to the additional effectiv
power gained, and considering that boiling-hot water will readil
part with the principal portion of its heat, it is proposed to tak
it back to the tender through a simple Refrigerator, in whic
advantage is taken of the rapid motion of the Engine throug
the air for cooling the water. The Refrigerator may be place
conveniently on the back of the tender.

The application of the proposed Condenser to low-pressu
Engines (see Fig. 2,' plate 39,) requires but a short notice, aft
what has been said already; the letters refer to the same parts
in the former description of the High-Pressure Condenser, show
in Fig. 1. In it the steam, at the time when it is release
from the cylinder, has not sufficient force to expel the air an
heated water from the Condenser into the atmosphere, and
partially vacuous space must be provided for their reception. F
this purpose, that side, B, of the displacing cylinder which, in th
arrangement hitherto described, is always empty, is put i
communication with the exhaust valve, G, of the Condenser, an
receives the charge of water and air at the time when the pisto
is at the opposite end. A second valve, O, is provided, throug
which the water is expelled into the hot-well during the retur
of the piston. For the convenience of arrangement, the dis
placing cylinder is reversed.

The chief advantages obtained by the application of this Con
denser to the low-pressure Engine are:—

1. The requisite amount of injection water is reduced in th
proportion of 3 to 1.

2. The feed water of the boiler is obtained nearly boiling ho
which constitutes a saving in fuel of $\frac{210-110}{1960}$ about 10 per cen

3. The whole amount of heat generated under the boiler i
given off by the Engine in the form of water, at 210° Fah., whic

t cases, may be advantageously employed for heating gs, for washing, dyeing, and other purposes.

large proportion of the power required for working the np is saved.

first Regenerative Condenser was attached to a 16-HP essure Engine, at Saltley Works, near Birmingham, in ber, 1849, where it has been found to answer, although it is fect in its proportions, and could not be kept constantly ration, in consequence of a deficiency of injection water. ual indicator diagram, shown in Fig. 3, Plate 30, was taken is Engine; since then, several more have been erected, e result above referred to obtained. The *dotted line* in shows the indicator diagram taken from the Engine before ndenser was applied, and the *full line* shows the diagram Engine working with the Condenser, and exerting exactly ne power as in the former case. The *shaded portion* of the n shows the power gained or saved by the use of the nser.

author proposes to conclude this paper with a short c sketch of the Steam Engine Condenser, to illustrate the t features of this proposed system.

Newcomen's Engine, the condensation of the steam was d by the alternate introduction of a jet of cold water into am cylinder itself. The cold water naturally cooled the of the cylinder, which in their turn condensed a large of the succeeding charge of steam before it had forced ton upward.

es Watt, in seeking a remedy against this loss of heat, ved the possibility of condensing the steam in a separate vessel; and in carrying his idea into effect, he not only d his immediate object, but at the same time rendered the Engine susceptible of that degree of perfection and general tion of which it is now possessed. The Injection Con- of Watt is the most effectual of its kind, and has main- its exclusive dominion to the present day. It consists of d vessel, which communicates periodically with the steam er. The injection water, together with the condensed

steam and air, which is partly evolved from the injection water, and partly leaks in through the joints of the cylinder and exhaust pipe, are continually discharged from it by means of the air-pump. Shortly after the introduction of Watt's Condenser, a Surface Condenser was proposed by Hornblower, which consisted of a close annular vessel of thin metal plate, on the inner surfaces whereof the waste steam of the engine was condensed; its latent heat being continually carried off by a stream of cold water which surrounded the vessel. A comparatively small air-pump was provided, which served to discharge the condensed water (to be again forced into the boiler) and some air which might leak in through the joints.

This Condenser failed in practice, for want of sufficient extent of cooling surface. An effective Surface Condenser would possess considerable advantages over the Injection Condenser, especially in the case of marine engines. Allowing the condensed steam to be continually returned into the boiler, it prevents incrustation of the latter, and, moreover, dispenses with the necessity of blowing off. Its air-pump absorbs a much smaller proportion of the power of the engine, and its functions require less personal attention. Stimulated by these considerations several attempts were made to improve on Hornblower's invention, but since all these improvements partake very much of the same character, it is thought sufficient for the present purpose to mention only Hall's Condenser, which has obtained the greatest amount of notoriety. It consists of two flat chests, or close chambers, which are connected together by means of a large number of brass tubes, through which the condensing steam circulates. These tubes are surrounded by cold water, which fills up the space between the flat chests. A small air-pump removes the condensed water and air from the lower chest. The great weight and costliness of this Condenser, its liability to derangement, and the impossibility of removing the calcareous deposit of the water from the tubes, without taking the whole fabric to pieces, are found to be heavy practical objections.

In the year 1847, the author had occasion to apply a Surface Condenser, in a situation where economy of space and material

were essential. In considering the most rational distribution of surfaces, he happened to find an arrangement which, with less than one half the amount of material used in Hall's Con-lenser, produced a very satisfactory result, and which paved the way to the more important improvement which forms the prin-cipal subject of this paper.

The Surface Condenser referred to, (see Figs 4 & 5, Plate 40,) consists of a number of copper plates, of $\frac{3}{32}$ inch thickness, and about $4\frac{1}{2}$ inches broad, by 2 feet long, which are fixed together by two ongitudinal flattened wires, of the same metal, between the djacent plates; and the whole pile is screwed up tight together etween the sides of a rectangular cast-iron vessel, which con-titutes the body of the Condenser. The ends of the plates roject through the top and bottom of the Condenser, and are laned flush with its exterior surfaces. The joints at top and ottom are secured by means of India-rubber rings, which are crewed down under small cast-iron frames, and yield to the ifference of expansion between the two metals. The flattened vires are laid parallel, about 3 inches apart from each other, and orm, with the plates, a large number of narrow passages, through which the cold condensing water flows in an upward direction, without entering the vacuous space of the Condenser, into which he edges of the plates outside of the flattened wires project, orming the condensing surfaces.

The *rationale* of this Condenser is as follows :—

The transmission of heat in a Surface Condenser is three-fold.

1. From the condensing steam to the internal metal surfaces.

2. From the internal surfaces, through the body of the metal, to its external surfaces.

3. From the external surfaces to the surrounding water by which it is carried off.

The first-named operation (condensation) would, it is pre-umed, proceed with undefined rapidity, if it were not retarded y the second and third, or by the presence of some permanent ases, which accumulate on the condensing surfaces, and prevent heir immediate contact with the steam. The second (conduction) aries in direct proportion with the conducting power of the

metal, and with its thickness; but the conducting power of copper is so great, that its thickness seems to exercise no appreciable influence on the amount of heat transmitted in a given time. This interesting fact is proved by Dr. Ure's experiment with two copper pans, of the same internal area, but very unequal thicknesses of bottom, (being in proportion as 1 to 12,) which were both filled with water, and dipped into a hot solution of muriate of lime. It was found that the water in the thick pan evaporated the quickest, which may be accounted for by its slightly increased external surface in contact with the heating solution; and this affords additional evidence that the limit of transmission does not lie within the metal, but rather between the metal surface and the liquid. That the absorption of the heat by the water is a slow process, may be inferred from the circumstance that water, although possessing a large capacity for heat, is a very bad conductor, and depends for its power to absorb heat on the slow circulation over the heating surface, caused by the inferior specific gravity of the heated particles of water. A strong artificial current along the heating surfaces greatly accelerates the process.

The Surface Condenser, above described, was arranged in accordance with these observations.

It contains :—Heat-absorbing surfaces, (by the water,) 18 sq. feet per horse-power; condensing surfaces, 9 sq. feet per horse-power; computed mean thickness of metal through which the heat is transmitted, 1¼ inch; weight of copper, 60 lbs. per horse-power; space occupied by plates, 0.4 cubic feet per horse-power; about one tenth part of the space occupied by the tubes in the Tubular Condenser.

The essential features of this Condenser are, its comparative cheapness of construction, and the easy access which it affords to the water channels between the plates.

It also requires less condensing water than previous Surface Condensers, in consequence of the repeated and close contact in which each particle is brought with the heating surfaces, before it can reach the upper reservoir, or hot-well. The author considers that the Surface Condenser just described may be

ntageously applied to marine Engines, and being not subject
patent, he hopes it will receive a sufficient trial.
ing required to save the waste steam of a low-pressure
ne, in the form of slightly-heated water, by Mr. John
am, of Manchester, the author, in the spring of 1847, con-
l the idea of a Regenerative Condenser. Figs. 4 and 5,
40, show his first arrangement, which may be termed a
nerative Surface Condenser. It consists of a revolving
B, which admits the waste steam of the Engine first to the
phere, at C, and, successively, into the separate compart-
s, D, E, F, G, where it is condensed at various densities.
cold water enters at H, and first passes between the plates
n the last compartment, and by degrees through those
n the first compartment, where the steam is of nearly
pheric pressure, and consequently heats the water to
y 212° Fah., when it passes out at I.
e next step was an Injection Condenser, on the same prin-
as represented by Fig. 6.
e revolving valve, B, admits the waste steam of the Engine,
to the atmosphere, at C, and then successively into the
ate compartments, D, E, F, G, where it is condensed at
us densities. The cold water is injected at H, and is passed
through the steam in each compartment in succession, by
s of the displacing pistons, K K, which work all on the
piston rod through each of the divisions between the com-
nents; and the heated water passes out at the bottom, at I.
L are overflowing distributing trays, for the purpose of
ing the water more rapidly and completely in contact with
team. M is a small pump to extract the air that is mixed
the steam and water.
e Regenerative Condenser, in its present form, partakes of
ature of both the Surface and Injection Condensers.
tempts have been made, from time to time, to condense the
n of a high-pressure Engine, without the aid of an air-pump,
owing the steam into a small Injection Condenser, which
ovided with a large exhaust valve.
is clear that the steam of high pressure will, at first, par-

tially blow through the Condenser, and rid it of its air and condensing water, and that, by degrees, the jet of cold water will overpower the influx of steam, and consequently produce a vacuum. An arrangement of this description, although simple, is at least very imperfect, because it is a matter of considerable difficulty so to proportion the injection of cold water, that the first rush of steam is not forthwith condensed, but may exert its expansive force in a cold vessel, and yet, an instant afterwards, effect a complete condensation of the remaining steam.

If too much water be used, the air and water will not be expelled, and consequently no vacuum be formed; if too little, no final condensation will take place.

The quantity of injection water must be very large, because the whole of the steam has to be condensed; and having to complete the condensation in the same vessel, it must leave it at a low temperature.

The principle of the Regenerative Condenser has been carried still further in the Regenerative Engine, which has been executed on a large scale by Messrs. Fox, Henderson, and Co., under the superintendence of the author. In it, the steam, after it has served to propel the working piston to the end of its stroke, is received into a series of consecutive chambers, from which it returns to the working cylinder an indefinite number of times.

On a future occasion, the author will be glad to bring the particulars of this Engine before the Institution.

Table of the Pressure of the Vapour of Water, from the Freezing to the Boiling point.

TEMPERATURE. Fahr.	PRESSURE. Ins. Mercury.	TEMPERATURE. Fahr.	PRESSURE. Ins. Mercury.
32	0·20	130	4·34
40	0·26	140	5·74
50	0·37	150	7·42
60	0·52	160	9·46
70	0·72	170	12·13
80	1·00	180	15·15
90	1·36	190	19·00
100	1·86	200	23·64
110	2·53	210	28·34
120	3·33	212	30·00

be required. It would then return to the tender in pipes, ...

r. Slate inquired, what difference had been found in the imption of fuel, in the engine at the Saltley Works, when ondenser was at work and when it was not at work?

r. Siemens replied, that the experiment had been tried one week's working with the condenser, and then one week ut it; and the saving of fuel with the condenser was at ate of 18 per cent. The apparatus with which the con- r worked was, however, too light, and had not been made e purpose; also, that condenser was the first that had been , and the proportions had been improved in the subsequent

r. Wright confirmed Mr. Siemens' statement of the saving el, and said there was a difference of about 8 cwt. in ys. There had been irregularities in the working of the e, and several stoppages had occurred from defects of the ratus, which was too light.

r. Siemens said, there was a deficiency in the supply of con- ng water, which sometimes interfered with the regular ing of the condenser, as well as the defects arising from earing being too light for working it, and these had caused ularities in the working of the engine; there was also a ulty in regulating the engine with the present governor, condensing engine. The steam pressure was 30 lbs. per ; but a smaller supply of condensing water would be ient, if a higher pressure of steam were employed.

e Chairman thought that, in a locomotive engine, the ordinary rapidity with which the jets of steam were dis- ged, constituted a great impediment to the application of ondenser.

r. Siemens replied, that it would only be necessary for the enser to work quick enough to condense one cylinder-full am before the next cylinder-full was discharged, and this he ght would easily be effected by widening the plates of the enser to a proportionate size, and shortening the stroke of ondenser piston, so as to reduce its velocity as far as might

be required. It would then return to the tender in pipes, between which air was caused to circulate by means of the rapid motion of the engine.

The CHAIRMAN observed, that there would be difficulty in keeping the water of the tender cool enough for condensing, when there was very little left in the tender; and the water remaining at the end of the journey, would be very hot and nearly boiling.

Mr. SIEMENS replied, that he expected the condensing water would be cooled down to about 100°, before it was returned to the tender, by the process of passing through the pipes of the refrigerator, from the rapid motion of the engine through the air; and the water was not required to be so cold as in the ordinary condenser, as only the last portion of the steam was condensed by injection.

Mr. COWPER observed, that only a small portion of the steam reached the injection water, the greatest portion being condensed previously, by the metallic plates, or discharged into the atmosphere; therefore the injection water might be about the same temperature as it usually came from the ordinary condenser. Also, the tender would not get empty so soon as usual, because a portion of the steam was condensed and returned back into the tender, instead of the whole being blown up the chimney: this gain might amount to one third of the water employed.

Mr. SIEMENS showed, by a comparative indicator diagram, that with the application of the condenser to a locomotive engine, the steam might be cut off at about one third of the stroke, instead of at two thirds as usual, and thereby a saving of one half the steam would be effected, with the same power.

The CHAIRMAN said, the subject of the application to locomotive engines was one of great importance, and he hoped it would be brought before the Institution in another paper. He proposed a vote of thanks to Mr. Siemens, for his paper, which was passed.

The following paper, by Mr. Archibald Slate, of Dudley, was then read:—

. NEW BLOWING ENGINE, WORKING AT HIGH VELOCITIES.

ormer meeting, the writer laid before the Institution the
ns which he entertained on the subject of Blowing Cylin-
proposed to be driven at high velocities, concluding that
would result thereby a large economy in the manufacture
throughout the entire plant and appliances of this indis-
ble machine. (See Report of Proceedings, July, 1850.)
as observed in the former paper that, since the application
double-acting movement, introduced some fifteen years ago,
owing Cylinder has remained, up to the present time, without
le other essential improvement. As left at that period, it
ues a large and cumbrous machine, with complicated and
motion; insomuch that the light and elastic body of the
phere is driven through at no higher velocity than the
ponderous body, water, can be passed through an ordinary
. While the motive power was derived, in most instances,
a waterfall, there might indeed be alleged some semblance
reason for the slow motion that has been spoken of;
gh, even in such circumstances, it is but little conceivable
he intervention of machinery, to quicken the passage of
ghter and elastic medium, should so long have remained a
eratum. But the question becomes infinitely more inex-
le, since the motive power employed has in almost every
ce been steam, itself a medium in the highest degree light
lastic; capable, at the same time, of being worked under a
ure, and at a velocity, far beyond anything required at
nt, or that probably ever will be required of the air from a
ng Cylinder.

ch being the facts, and contemplating the power and speed
od on the Railway by Locomotive Engines, the writer was
reflect that a similar power was at least capable of being
d to the Blowing Cylinder; and, while impressed with
rain of thought, he had occasion, in the latter part of the
848, to make use of some small 9-inch cylinders, driven by air
a larger Blowing Engine. It was then remarked that

these small Engines, when driving shafts only, sometimes attained a velocity of 200 revolutions per minute, under the ordinary blast pressure; when the idea suggested itself, that it might be possible to reverse their motions, making them Blowing Cylinders in place of Air Engines; and this idea, on being tested, turned out to be correct.

The cylinder experimented on was of 9 inches diameter, and one foot stroke, and being driven at the rate of 320 revolutions per minute, discharged the air at 3½ lbs. per square inch, through a tuyere of 1⅛th inch, being exactly $\frac{1}{64}$th part of the area of the blowing piston. This performance exceeds, as is well known, by double its amount, that of any ordinary Engine; the total area of the tuyeres, with a 90-inch Blowing Cylinder, at a pressure of 3½ lbs., being about 50 circular inches, which is only $\frac{1}{144}$th part of the area of the Blowing Cylinder.

Assured by the complete success of this experiment, the writer proposed to construct a Steam and a Blowing Cylinder of two-feet stroke; the cylinder for steam to be of 10 inches diameter, and that for blast of 30 inches; and to couple them, if necessary, with a second and similar set, acting at right angles upon a common axle; and he is still of opinion that such would probably prove the best arrangement, as well as the best proportions to observe in construction. (See Plate 11, in Proceedings, July, 1850.)

But in the actual experiment, the cylinders proposed to be placed at right angles have not yet been constructed. The size of that used, owing to peculiar circumstances, has been considerably enlarged. In 1850, finding that more air was required for the manufacturing purposes to which it was applied, the writer and Mr. Cochrane (his partner) resolved to make a Blowing Cylinder of such a size as would practically test the question of high velocities; and a Steam Engine, having a Cylinder of 14 inches diameter, being ready at hand, was fitted with a 40-inch Blowing Cylinder, and to this Engine the further remarks have reference. The stroke is 2 feet; the total weight of the Engine about 6 tons; the boiler made use of weighed 3 tons, 13 cwt.; its length over all is 27 feet, having egg ends; its diameter 4 feet.

first set of experiments were made in presence of Mr. Mr. McConnell, Mr. Daniel Geoch, Mr. Geach, Mr. Evers, chrane, and several other gentlemen who took an interest proceedings, which were of the following nature.

he outlet pipe were placed four tuyeres: two of them 2¼ diameter, and the remaining two 2 inches diameter, all g into the open air. The Engine being run up to its full y, reached 145 strokes per minute. At this rate, the of the air issuing from the four tuyeres approached to 5 lbs. per inch, the Engine remaining perfectly noise-nd steady, and the blast being so continuous and regular, e mercury in the barometer did not vary more than ⅛th nch—in fact, continued barely living in the tube.

ariety of minor experiments followed, not necessary to be upon at present; but it is believed perfectly warrantable e, as the result, that each person present felt convinced e had seen exhibited a Blowing Machine of at once a ful, cheap, and efficacious character.

ough the experiments thus detailed were of the most ctory description, and indeed had exceeded every expec- of a first performance, the writer nevertheless felt con-l, from observation of the working, that the steam might nsiderably economised; and before proceeding to apply it ual use, resolved to fit the engine with an adjusting ex-e valve, by which such economy might be realised. When d been fitted, and the requisite attachments made, its full ement of blast was thrown into one furnace, viz.: 3500 feet of air per minute; the pressure of the air in the main, upon the engine, was a little in excess of 3 lbs. to the at the tuyeres on the furnace, it was, if anything, rather 3 lbs.: but this slight discrepancy probably took its origin the tortuous character and length of the main, which ex-l 300 feet; a circumstance which it was found impossible oid, without leaving out of consideration the objects to the new blowing power is ultimately to be applied.

e Engine, during the trial, varied from 96 to 100 strokes inute. The steam from the one small boiler, 27 feet by 4,

remained full and sufficient for this work, after the Engine had worked every day for nearly a month, and had been seen by Mr. Benj[n]. Gibbons, and several other persons connected with the iron trade. An opportunity again occurred of trying it upon one furnace, with the same result as above; this last experiment was made in the presence of Mr. Samuel Blackwell. With regard to fuel, on a subsequent trial, while working in connection with a larger Blowing Engine of the ordinary sort, delivering into the mains 3000 cubic feet of air, at a density of $3\frac{1}{4}$ lbs. to the inch, it was found to amount, by measurement, to 2 tons 5 cwt. of small refuse coal, or slack, in twelve hours.

Although the writer does not present the arrangement of the Engine, here given, as a perfect machine, he can entertain no doubt that the development of the principle must greatly stimulate the production of iron. It will be perceived how, by the use of Blowing Machines, working at high velocities, the expense of plant and machinery for blowing a furnace may be reduced, at the rate of 65 per cent., from what it stands at present; or, to one third of the present amount. The above-mentioned experiments at Woodside have proved such Engines to be adequate to as large a class of works as exist in Staffordshire. Their simplicity and portable character make them equally available at the smallest charcoal furnaces, in however remote a quarter there might be occasion for their use.

Mr. Middleton inquired, whether the blast from the small engine went direct to the furnace, or through a reservoir?

Mr. Slate said, they had a receiver, 12 by 4 feet; but in the experiment with one furnace, when the other was in repair, they let it blow through the whole of the large air main.

Mr. Middleton said, that he remembered the late Mr. Murdock worked a similar blowing engine at Soho, twenty-five years ago; it was direct-acting, and the only difference was that it had a D valve, and worked at a slower velocity than Mr. Slate's engine.

The Chairman said, he had a similar blowing engine in

ar work at Wolverton, only working vertically instead of
ontally; but his engine only made from fifty to sixty strokes
inute, while that now under description performed one
red and thirty in the same time. This gave the blowing
e of Mr. Slate a great advantage, and was its distinctive
e; the great gain was in the high speed employed.

. DAVIES observed, that Mr. Slate's engine could give a
blast for a furnace, with full pressure, which Mr.
ock's engine could not do.

. SLATE remarked, that, though Mr. Murdock's engine
een at work at Soho for the period stated, no further
ess had been made in the construction of the blast engine;
Soho they still continued to make only the old ponderous
es.

. MIDDLETON said, it had been applied at the smithy at
wich, and had been at work there for many years. He
ht, though Mr. Slate's engine was different in some
ts, it was similar in principle to Mr. Murdock's.

. W. SMITH was quite satisfied that Mr. Slate's engine
maintain a constant blast for a furnace. He had seen
Iurdock's engine at work; it was an open-top cylinder,
as quite another kind of engine. He thought that Mr.
s plan of blowing engines was an important advantage
saving of expense in the erection of iron works, and he
ed that a blowing engine could now be erected for £500
at plan, as well as one on the old plan for £1500, to do
me work.

e CHAIRMAN thought that Mr. Slate's engine was certainly
ing of approbation, and he hoped that he would con-
his investigation of the subject, as any improvement or
my in the manufacture of iron was of great importance.
ote of thanks was passed to Mr. Slate for his communi-
.

e following paper, by Mr. E. A. Cowper, of Birmingham,
hen read:—

ON AN IMPROVED MODE OF MOULDING RAILWAY CHAIRS.

In laying before the Institution a short account of a new mod of casting Railway Chairs, it is thought that no apology i necessary for the introduction of such an apparently dry matte of detail, as it has ever been the great aim and object of thi Institution to thoroughly discuss, and, as far as possible, pass a sound practical judgment on, mechanical inventions affectin the interests of the public generally.

The improved mode of casting Railway Chairs is confidentl submitted to the judgment of the members; and as the inventio is simply a *cheaper mode* of producing *better castings*, it may b described in a very few words.

The importance of a Railway Chair being a strong, *accurate* and *sound* casting, must at once be apparent to every mechanica man; and, indeed, it is probable that the majority of the members present have travelled over many hundred thousand chairs during the past week, the failure of any one of which might have been attended with most serious consequences.

Now, if it can be shown that, in addition to producing a more *perfect casting*, it can be done at a *cheaper rate* than usual, it is presumed that the new mode may be considered an *improved* method of casting Railway Chairs.

On referring to the engraving, (Plate 40,) it will be seen that A A, in Fig. 1, is the iron *pattern;* and it is necessary here to observe, that the inside of the *pattern* is *not* the shape of the intended Chair, but the edges of the jaws are provided to receive cast-iron *chill-plates*, B and C, which are made so as to give the required form to the inside of the casting. These *chill-plates* are dotted in Fig. 1, and they are shown separately in Figs. 2 and 3, and in section, in Fig. 4.

The *pattern* being placed in the moulding box, as shown in Fig. 1, the chill-plates are placed therein, one in contact with each jaw of the pattern. The sand is now thrown into the box, and some of it is rammed between the chill-plates, thus effectually securing their close contact with the pattern; the

ainder of the sand is then rammed in, until the box is full. box and its contents are then turned upside down, in the il way; the pattern is slightly rapped, and then withdrawn, neans of a screwed lifting-pin; the chill-plates being left in sand, forming a good guide to the pattern as it is withdrawn. top box is then put on, having previously been rammed up another board, technically called an "odd-side board;" the ed metal is then poured in, and the casting is complete. As as the metal has thoroughly set, the casting may be turned and the *chill-plates* will *drop out of themselves.* The finished r is shown in Fig. 5, and D D are the two portions that are in the chills, B and C.

ne box exhibited to the meeting has been rammed up in the ner described—the chill-plates may be clearly seen, firmly dded in the sand; and it is remarkable what great force is ssary to displace them.

ne chill-plates are simply good castings, made from an iron rn, and are not filed up, or fitted in any way, as the iron rn of the Chair is fitted to them, and the metal-chills being ly pressed by the sand against the metal pattern, great racy is obtained in the position of the chills; indeed, it is y rare thing for the shape or inclination of the jaws of the r to vary anything like $\frac{1}{32}$nd of an inch; therefore, when the ght-iron rail is placed within the Chair, the correct inclina- is accurately given to it; and if the rail be true, the Chairs ot be *winding*, or out of parallel with each other.

is found that the chill-plates stand exceedingly well, and in nany hundred tons may be cast off one set of them; this rtly owing to their not being very thick, so that they soon ot through, and do not strain or warp at all; the Chairs are d just sufficiently to give a good, true face, but are not d-in very deep, in consequence of the chill-plates not being thick, and the Chairs themselves containing a large quan- f metal.

this plan of casting Chairs, boys only are employed for ding, as the great ease and safety with which the pattern is rawn entirely does away with the necessity of regular

moulders being employed; thus the cost of manufacturing Railway Chairs is brought to a minimum.

In conclusion, it may be stated that many thousand tons have already been cast on this plan, and that it bids fair to be uni versally adopted.

Mr. COWPER exhibited specimens of the chairs and the patterns, and the process of moulding. He said that, by that process of casting, there were scarcely any wasters made, not more than one in five hundred, which effected a great saving in the expense.

Mr. SLATE said, the plan proposed was unquestionably very simple and ingenious, and one which any boy might easily be taught to understand. He wished to ask Mr. Cowper what he considered the saving in expense would be, by his plan?

Mr. COWPER observed, that none but boys were employed in the moulding of the chairs. The saving, he considered, in an ordinary way, would be about four shillings per ton.

Mr. MIDDLETON enquired, what was the difference in the plan of casting chairs from that of Messrs. Ransome and May?

Mr. COWPER explained, that their plan was to have an iron plate or chill fitting the side of the box, and the chill-block fixed into that by a small dovetail. This block had to be driven out before the chair cooled, and the chairs sometimes were strained by the contraction before the block could be got out, and were broken or injured; but in his plan there was no strain in cooling. Also, his plan ensured the inclination of every chair being quite correct, because the chill-plates were held so firmly; but in that of Messrs. Ransome and May, there was a degree of uncertainty in the inclination, from the block being held only at the side. He might mention, that they had so far approved of his plan as to arrange for adopting it in their manufacture. His chair could be made perfectly parallel

le, but in their chair there was obliged to be a little taper le, to allow of driving out the block after it was cast.

n the old chairs they were compelled to use taper keys, which uently got loose, but with this chair the keys could be used e parallel, and when they became swollen by the moisture, ed a head at each end, which prevented the keys from ever ng loose.

he CHAIRMAN observed, that Mr. Cowper's plan appeared to decided improvement, both in the accuracy of casting the rs, and in economy of manufacture; and he proposed a of thanks to him for his paper, which was passed.

he CHAIRMAN announced that the ballot lists had been ed, and the following new members, &c., were duly ed :—

MEMBERS :

JOHN ADDISON, London.
WILLIAM BATLEY, London.
CHARLES NIXON, Cork.
EBENEZER ROGERS, Abercarne.
CHARLES W. SIEMENS, Birmingham.
JAMES THOMPSON, Manchester.

GRADUATE :

J. THORPE POTTS, Birmingham.

HONORARY MEMBERS :

THOMAS D. CLARE, Birmingham.
WILLIAM D. STARLING, London.

he meeting then terminated.

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INSTITUTION

OF

ECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

.D IN BIRMINGHAM, ON 22ND OCTOBER, 1851.

ARCHIBALD SLATE, ESQ.,

IN THE CHAIR.

BIRMINGHAM:
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1851.

PROCEEDINGS.

[Th]e General Meeting of the Members was held at the [Hous]e of the Institution, Newhall Street, Birmingham, on Wed[nesda]y, 22nd October, 1851, Archibald Slate, Esq., in the [Chair].

[Th]e Secretary read the Minutes of the last General Meeting, [which] were confirmed.

[Th]e Chairman announced that, according to the Rules of [the I]nstitution, the President, Vice-Presidents, and five of the [Counc]il, in rotation, would go out of office next year; and that, [at the] present Meeting, the Council and Officers for the next [year w]ere to be nominated for the election at the next Annual [Meeti]ng. He then read the following list of Members, proposed [by the] Council for nomination, with the addition of any other [Memb]ers who might be proposed by the Meeting.

President:

* Robert Stephenson, M.P.

Vice-Presidents:

(*Three of the number to be elected.*)

* Charles Beyer, Manchester.

Edward Humphrys, Woolwich.

Edward Jones, Bridgewater.

* J. E. McConnell, Wolverton.

* John Penn, London.

R. B. Preston, Liverpool.

Archibald Slate, Dudley.

COUNCIL:

(*Five of the number to be elected.*)

JAMES BROWN, Birmingham.
P. R. JACKSON, Manchester.
* MATTHEW KIRTLEY, Derby.
* JAMES KITSON, Leeds.
JOHN R. MCCLEAN, London.
* RICHARD PEACOCK, Manchester.
* R. B. PRESTON, Liverpool.
* JOHN RAMSBOTTOM, Manchester.
THOMAS RICHARDS, Worcester.
THOMAS WALKER, Wednesbury.

TREASURER:

* CHARLES GEACH, M.P., Birmingham.

SECRETARY:

* WILLIAM P. MARSHALL, Birmingham.

(The Officers for the present year are marked thus *.)

No other names having been added by the Meeting, the above list was adopted.

The following paper, by Mr. JAMES A. SHIPTON, of Manchester, was then read:—

ON THE DIRECT CONVERSION OF RECTILINEAR INTO CIRCULAR MOTION IN THE STEAM ENGINE.

The years that have elapsed since the Steam Engine was first generally introduced as a prime mover, and the few alterations that have taken place, notwithstanding the many threatened invasions of

ariety of ingenious inventions, must lead to the reflection that
y a master mind could have combated with the difficulties that
et such an undertaking, and have sent it forth to the world in so
fect a form; the unskilled hand of the workman being the only
wback from its being then what it is now.

The costly work of the various parts subjected to immense strain,
also to the searching and penetrating action of steam, depended
n entirely upon the manual dexterity employed, and therefore
machinery of the Steam Engine was required to be of the most
ple form to place it within the reach of even the most opulent;
as its use and value presented itself to the country at large, so
development of machinery took place to meet the demands of
nanufacture; and, though it must be acknowledged that the same
d that brought the Steam Engine into commercial operation,
templated also the reduction of its cost, by the use of self-acting
chinery in the production of its parts, yet the task of bringing
h into operation has been nearly as arduous as the former one.
at the mechanic would then have looked upon as an impossibility,
ow perfectly simple, and the cost in comparison trivial.

That the principle of the ordinary Steam Engine as regards the
procating action of the steam cannot be improved, is the
hor's opinion; but also that its mechanical construction may be
erially altered, and improvements effected in this respect, owing
he many advantages possessed at the present time of having tools
neet every requirement; the rapid progress made in this branch
mechanical science having placed the Steam Engine in its
sent commercial position.

The subject of the present paper is the "Direct Conversion of
ctilinear into Circular Motion," and also brings under notice a
am Engine, not deviating in principle from the ordinary recipro-
ng engine. but simply in its construction; as the inventors feel
vinced the nearer they approximate to the original the less liable
y will be to err. The diagram, Figure 1, Plate 42, represents a
ton and crank engine of ordinary construction, and although the
ole area of the piston be exposed to the pressure of the steam
oughout the stroke, (supposing the valve be kept open,) there
certain points when this pressure is useless, namely, when the

crank is on the centre; thus, the circular motion of the crank restricts the piston from exerting its full force with regard to that circular motion, and thereby the velocity of the piston is constantly varying throughout the stroke, as also the power exerted and the steam consumed in like proportion. Thus the actual power exerted is the average velocity of the piston multiplied by the pressure.

Now, an eccentric being a mechanical equivalent for a crank, if the area of the piston of Fig. 2 be equal to the area of the piston of Fig. 1, and the throw of the eccentric, B, equal to the stroke of the crank, A, they are of like power.. Then, by altering the mechanical arrangement, as in Fig. 3, and placing a piston at top and bottom of the eccentric, or, in other words, placing the eccentric in a large piston, the area of piston and throw of eccentric being equal to B, an engine of like power is obtained. Therefore, A, B, and C, are equivalents of each other, differing only in mechanical construction; and the power obtained from each would be the same, not taking friction into consideration.

Dispense with these pistons, and admit steam alternately, top and bottom of the circle, D, in Fig. 4, and this eccentric piston would be propelled, up and down, in a rectilinear direction, and this motion would be converted into a circular motion, during the propulsion of the piston. Here is obtained the amalgamation of the two motions of the ordinary engine in one body; the same body containing the properties of the reciprocating piston, and also of the crank.

The practical application of this principle is effected in the Pendulous Engine, shown in Figures 5, 6, 7, Plates 42 and 43; these represent a 20 horse-power steam engine, which is a modification of an engine that was submitted by the author to a former meeting of the Institution.

A is the base-plate, that carries the entire engine. The side framing, B B, is fitted to it, and bolted firmly down, and upon this the cylinder, C, is suspended, and swings with a pendulous action. The piston, D, is turned perfectly true, having the shaft, E, keyed eccentric in it. This shaft works in pedestals, P P, which are fixed on the bed-plate. The piston works between two parallel

s, F and G, the surface at F being a plate, dove-tailed into inder, and the plate G is fitted into the recess prepared for so arranged that, by means of adjusting screws, it follows up ar that may take place on the periphery of the piston, and main- steam-tight joint. The piston is packed at the ends with the H H, these being fitted into a conical seating, and as the wear lace, they are sprung open by means of a small wedge and bolt d where the ring is cut open, to allow it to expand. These work against the side plates, I I, which are bolted to the r, and have metallic joints. The peculiar motion of the ends piston against these surfaces causes a most beautiful wear, rings keep receding in their seatings, and never come over ne parts twice together.

am is admitted precisely the same way as in an ordinary , at top and bottom of the piston, but the valve, N, is on the rium principle, and exhausts through the back, being by a conical ring, in a similar manner to the ends of the ; the valve is worked by the eccentric, J, by means of levers eigh shaft. The steam and exhaust pipes are shown at K and are packed with the glands, M M, to admit of the ous motion of the cylinder. The distances between the s are calculated so as to allow the pendulous motion of the r to coincide with the rate of revolution of the engine, and uently, only a small portion of the weight of the moving as to be overcome, with respect to the vibration.

e advantages of this Engine are,—economy in first cost,— ny in space,—economy in foundations, being self-contained, plicity and economy in repairs, as the wearing parts are ons, and may be renewed at a short notice,—direct appli- of the steam to produce the rotary motion of the shaft, t the intervention of joints or connecting rods,—and not liable to derangement, as the moving parts are so few in r. As it contains less frictional surface than the ordinary , economy in consumption of fuel may be expected. High may be obtained, and thus gearing, wheel-work, &c., may be sed with; and from its compactness, this engine is most le for working the heavy class of machinery, such as rolling-

mills, &c., or screw-propellers in steamboats. A twenty-hors engine is being constructed on this plan, and will be at work in few days, and the author will be ready, at a future period, to la before the Institution its performances, tested by a dynamometer.

Mr. SHIPTON exhibited a working model of the Pendulou Engine, and illustrated its action by sectional models.

Mr. ELWELL enquired whether a similar Engine had not bee at work for a considerable time at Wolverhampton? and wha was the probable cost of such engines?

Mr. SHIPTON replied, that the engine at Wolverhampton wa constructed on the former modification of the plan, in which th piston oscillated instead of the cylinder. The cost would be £ per horse-power, exclusive of the boilers. The only comparativ trial that had yet been made as to the consumption of fuel, wa with an engine at Manchester, which showed a saving of 10 per cent., as compared with another direct-acting engine whic worked from the same boiler.

Mr. SIEMENS enquired how the packing was made steam-tight? And Mr. SHIPTON explained that it was by an expanding ring of triangular section, giving an equal pressure on both surfaces: the same plan was adopted for packing both the piston and the valve. He exhibited one of the packing rings.

Mr. CLIFT observed, that Mr. Shipton had argued that a considerable saving would be effected by avoiding the crank motion and the reciprocation of the piston; but he had against that the whole weight of the cylinder in motion, which was a large weight to be stopped and reversed at every revolution; and therefore he could not see what advantage the invention possessed over the ordinary engines.

Mr. SHIPTON replied, that the pendulous motion of the cylinder prevented the loss of power in reciprocation; the cylinder

ed as a pendulum; and they found that one man could the cylinder of a 20-horse engine in vibration, at full speed.

r. CLIFT enquired whether the cylinder was made of correct to vibrate, according to the law of a pendulum, at the actual ng speed of the engine? as, if not correctly adjusted, it might e a large amount of power to force it into the required rate ration.

r. SHIPTON said, the remark would apply to all oscillating es, but in this engine they had calculated the length of the s of oscillation, so as to agree with the intended rate of ng of the engine.

r. SIEMENS observed, that weight was certainly of secondary leration, if the centre of oscillation could be made to agree he corresponding length of pendulum; and such an arrange- would make the power more uniform throughout the stroke. would not be correct to consider the weight of the piston ss, in a reciprocating engine, as the momentum was gradually bed by means of the crank, and given out again in starting turn stroke. In some cases a heavy weight of piston and cting rod was actually an advantage; an expansive engine, g off at half stroke, worked more steadily with a heavy con- g rod than with a light one, as it absorbed surplus power at art of the stroke, and gave it out again when the moving was deficient, tending to equalize the power. With respect . Shipton's engine, he considered the question to be one of rative friction, compactness, and simplicity.

he CHAIRMAN understood Mr. Shipton to bring forward his e rather as one presenting advantageous points of construc- han as one which led to saving in fuel. He proposed a vote nks to Mr. Shipton for his communication, which was passed.

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he following paper, by Mr. J. E. Clift, of Birmingham, was ead:—

ON THE PRESERVATION OF TIMBER BY CREOSOTE.

In the present day, when the requirements for timber, in the various mining, engineering, and other works, are so great, it becomes necessary to consider carefully the best means of renderin it as durable as possible, and that at the least expense; and th writer cannot think that sufficient attention has been paid to th subject by the parties most interested, from the fact that but few o the larger consumers of that article have adopted any plans for it preservation; and this fact must be the apology for bringing befor the Institution a paper upon a process which has been partially i use for several years.

In looking through the colliery districts, it is found that thousand of loads of timber are taken green from the forests and used ever year; and the greater portion is used in the pits, where, owing t damp atmosphere and increased temperature, it is rotted in a fe months; whereas, with a small expense, it might be made to las for years.

It may be observed, also, that the Railway engineers are seekin for a more durable bearing for the rails in iron sleepers, and over looking the means of making wood, which is allowed to be the mos agreeable for travelling upon, the most durable as well as the mos economical material for the permanent way.

Wood may be briefly stated to be composed of a fibrous tissue which upon examination with the microscope is found to consist o longitudinal tubes, arranged in concentric rings around the centr pith; these tubes varying in diameter from $\frac{1}{2000}$th to $\frac{1}{200}$th part of a inch. The use of these tubes in a growing tree is to convey th sap from the root to the branches; and after the tree is cut up fo use, they contain the chief constituent of the sap, vegetable albume —a substance very much resembling in its composition anima albumen, or the white of an egg. Different woods vary in the pro portion which they contain of this substance, but in the softe woods it averages one per cent.

The dry rot in timber is caused by the putrefaction of the vege table albumen, to which change there is a great tendency; an

n once this has taken place, it soon infects the woody fibre, cing decomposition, and causing its entire destruction.

Many plans have been proposed to arrest this evil, each with e or less success; the chief aim of the authors being to coagulate lbumen by means of metallic salts, and so prevent putrefaction. ng others may be mentioned the following, as being the most essful:—Kyan's process, by the use of chloride of mercury; nett's, by chloride of zinc; and Payne's, by sulphate of iron and ate of lime, forming an insoluble precipitate in the pores of wood. To each of these plans there are serious objections in tice. In the first place, when metallic salts are injected into er in sufficient quantities to crystallize, the crystals force open pores, causing a disruption of the fibre, and when the timber wards becomes wet they dissolve, leaving large spaces for the ment of water, and rendering the timber much weaker. Secondly, metallic salts being incapable of sealing the pores of the wood, fibre is still exposed to the action called éremacausis, a process xidation, after the albumen has been precipitated. These pro- es are also objectionable for wood that requires iron inserted in ttached to it, as the acids act upon the iron in a manner well wn, and ultimately destroy it.

The plan that is the subject of the present paper is the one nted by Mr. Bethell, for the use of a material obtained by the llation of coal tar. This material consists of a series of bitu- ous oils, combined with a portion of Creosote; this latter sub- ce being acknowledged to possess the most powerful antiseptic erties. The action of this material may be thus described:— en injected into a piece of wood, the Creosote coagulates the men, thus preventing the putrefactive decomposition, and the minous oils enter the whole of the capillary tubes, encasing the dy fibre as with a shield, and closing up the whole of the pores, s entirely to exclude both water and air; and these bituminous being insoluble in water, and unaffected by air, renders the ess applicable to any situation. So little is this oil affected by ospheric change, that the writer has seen wrought-iron pipes had merely been painted over with it, and laid in a light ground

one foot beneath the surface, taken up after twenty years, and the appeared and smelt then as fresh as when first laid down.

By using these bituminous oils, the most inferior timber, an that which would otherwise soonest decay, from being more porou and containing more sap, or being cut too young or at the wron season, is rendered the most durable. This will be readily unde stood, when it is considered that this porous wood will absor a larger portion of the preserving material than the more clos and hard woods: in fact, the soft woods are rendered hard by thi process. By this means, therefore, Engineers will be enabled t use a cheaper timber with greater advantage than they could us a more expensive timber uncreosoted;—thus, taking the cost of sleeper of American yellow pine at 4s., and one of Scotch fir at 3s and then adding 1s. to the latter for creosoting, the two would b the same cost; but the former one would last under the mos favourable circumstances not more than ten or twelve years, an the other would be good under any circumstances in all proba bility in a hundred years.

This system of preserving timber has been in use on severa railways, and other works, for several years past. A portion of th London and North Western Railway, about seventeen miles i length, has been laid with the creosoted sleepers from nine t eleven years, during which period, the engineer reports that n instance has occurred in which any decay has been detected i them, and they continue quite as sound as when first put down On the Stockton and Darlington Railway, creosoted sleepers hav also been laid for ten years, and are found to continue without an appearance of change or decay; also on the Lancashire and York shire Railway, creosoted timber has been used for five years, as pavin blocks, posts, &c.: the upper part becomes very hard, and the par under ground appears as fresh as when taken out of the creosot tank, though the timber was of inferior, sappy quality. In a tria commenced twelve years since, by Mr. Price, of Gloucester, of the comparative durability of timber in the covers of a melon-pit, where it was exposed constantly to the combined action of decom posing matter and the atmosphere—the unprepared timber became decayed in one year, and required replacing in a few years; a portion

ie timber that had been kyanised lasted well for about seven years, then gradually, though very slowly, became quite decayed; but timber that had been creosoted still continues as sound as when put down, twelve years since.

From these facts, it appears not unreasonable to infer, that if oer be made to continue unchanged, and to show no symptom lecay for ten or twelve years, under circumstances that reduce repared timber to dust in two years, and in the absence of any of to the contrary, we may expect to find that it will last an mited period, and that one hundred years will be a moderate to assign to it.

And not only does this creosoting process render wood free decay, but it also preserves it from the attacks of the teredo n, when used for ship-building, harbours, docks, and other contiguous to the sea.

This has been satisfactorily proved at Lowestoft harbour, where plan has had a very extensive trial for four years; and the rintendent reports that there is no instance whatever of an eosoted pile being sound, they are are all attacked by the oria and the teredo to a very great extent, and the piles in e instances are eaten through; but there is no instance what- of a creosoted pile being touched, either by the teredo or the oria, and all the creosoted piles are quite sound, though red with vegetation, which generally attracts the teredo. This ordinary fact is to be accounted for by the creosote remaining t in the timber, either wet or dry; and, being destructive to animal life, is proof against the attack of these parasites;— eas, with the other processes, the metallic salts are washed or that portion which unites with and coagulates the albumen ndered quite innocuous by the process. It will be seen by the imens exhibited that the ravages of the worm reduce the un- ared timber to a completely honeycombed state in two years' the creosoted timber remains untouched after a period of four s.

There are two processes in use by Mr. Bethell, for impregnating oer with creosote;—one is by placing the wood in a strong iron

cylinder, and exhausting the air from it by an air-pump, until a vacuum is created, equal to about twelve pounds on the square inch; the creosote is then allowed to flow into the cylinder, and afterwards a pressure is put upon the creosote, by a force-pump, equal to about 150 pounds on the square inch; the timber then taken out is fit for use. This apparatus is shown in Plate 44.

A The wrought-iron pressure tank.
B Cast-iron cover, fixed by strong clamps and screws.
C Small crane, for removing the cover.
D Carriages for holding the timber, E, that is to be creosoted. These carriages run on a railway in the tank, for facilitating the charging and discharging of the tank.
F Iron cramps, fixed to the carriages, for confining the timber to the proper space for entering the cylinder. Small blocks of wood are used to keep each piece of timber a certain space from any of the others.
G Reservoir for the creosote.
H Steam-pipe, for warming the creosote.
I Steam-engine.
K Air-pump, for exhausting the pressure tank.
L Force-pump, for injecting the creosote.
M Discharge pipe, for emptying the tank, with safety valve, for letting off the superfluous creosote, when the required pressure has been attained.

The second process is by placing the timber in a drying-house, as shown in Plate 45, and passing the products of combustion through it; thereby not only drying the timber rapidly, but impregnating it, to a certain extent, with the volatile oily matter and creosote contained in the products given off from the fuel used to heat the house. When the timber is taken out of this house, it is at once immersed in hot creosote in an open tank, thus avoiding the use of a steam-engine, or pumps.

AA Drying-house, built with hollow walls, filled in with ashes.
B Fireplace.
CC Flue, running the whole length of the building, covered with iron plates, perforated for half the length farthest

from the fire, to allow the products of combustion to pass through the timber on the way to the chimney.

D Carriages, for holding the timber, E, that is to be creosoted, running on a railway for facilitating the charging and discharging of the drying-house.

F Iron doors, closing the end of the drying-house.

Mr. CLIFT exhibited specimens of Creosoted Sleepers, which d been in use for ten years on the London and North Western ilway, near Manchester, and were still perfectly sound and changed; also specimens of Creosoted Piles from Lowestoft rbour, which had been in the sea for four years, and continued te fresh and sound, and without being touched by the worm; h specimens of similar piles uncreosoted, from the same situ-on, which were completely eaten away and honeycombed by worm in the same period.

Mr. BETHELL observed, that when he first commenced to pre-ve timber, he found that no pressure would get the creosote into timber from the presence of moisture in the pores, and it be-ne necessary to adopt the system of drying the timber first; and er fourteen days he found that the wood lost 3 lbs. in weight every cubic foot; this was by the old process of drying. He en introduced the present drying-house, and in twelve or four-en hours they lost 8 lbs. per cubic foot, in Scotch sleepers, and ese then absorbed an equal weight of creosote. An average 11½ lbs. of creosote per cubic foot was now put into all the emel timber at Leith harbour works; it was forced in with a essure of 180 lbs. per inch. One piece of creosoted timber had en observed at Lowestoft, which had been half cut through for a ortice, but not filled up again, and a teredo had penetrated a little y into it at that part, and then attempted to turn to the right, d then to the left, and had ultimately quitted the timber with-

out proceeding any farther. Young wood was the most porou round the exterior, and consequently absorbed most creosote, whic formed a shield to keep off the worm. The creosoted sleepe were better after eight or ten years than when new, because th creosote got consolidated in them and rendered them harder. H had taken the idea originally from the Egyptian mummy; it wa exactly the same process; any animal put into a creosote tan assumed the appearance and became in like condition to a mummy Timber creosoted was now chiefly used in railways, but h believed that if it was introduced into coal-pits it would be foun that no timber so used in those places would rot.

The CHAIRMAN remarked that if the owners of pits found so much to their advantage, he was sure the plan would come int use.

Mr. CLIFT said he had taken up the subject in the presen paper with that view; his object was to draw attention to pi timber, and he was satisfied that if the timber used in coal-pit was creosoted, it might, when done with in one situation, be agai taken out to use in another place; whereas now, because the dr rot seized the timber so quickly, it was left behind in the working of the pits.

The CHAIRMAN enquired whether, in the process of creosoting the quantity of sap extracted was calculated? and how the exac quantity of creosote that was put into the timber was ascer tained?

Mr. BETHELL replied, that every piece of timber was weighe before it was put into the creosote tank, and again when take out, and each piece was required to be increased in weight by th process 10 lbs. per cubic foot; the quantity of oil used alway rather exceeded the weight gained in the timber, on account o the loss of weight from the moisture extracted by the exhaustio of the air-pump.

The CHAIRMAN enquired what difference was found in th quantity of creosote absorbed by the harder woods?

Mr. BETHELL replied, that oak only absorbed half as muc

osote as Memel timber. Common fir creosoted would last ıble the time of hard wood creosoted, because it took more osote. Beech made the best wood, being full of very minute es, and they could force a greater quantity of creosote into ech than into any other wood; consequently it took a more form colour throughout from the process.

Mr. SHIPTON enquired how the process was regulated to ow for the difference in size of timber?

Mr. BETHELL said that long pieces of timber were found to uire more time to saturate them in proportion to their length, l the creosote appeared to enter at the two ends and be forced through the whole length of the pores. The progress was own by the quantity of creosote forced into the tank after it s filled, according to number of cubic feet of timber contained the tank.

A vote of thanks was passed to Mr. Clift for his communica- n; and the following paper, by Mr. Archibald Slate, of Dudley, s then read:—

EW EQUILIBRIUM CANAL LIFT, FOR TRANSFERRING BOATS FROM ONE LEVEL TO ANOTHER, WITHOUT LOSS OF WATER OR OF POWER.

The scarcity of water in the inland navigation during the sum r months, and the consequent inconvenience to the manufacturers o are dependent for an outlet on that mode of conveyance, having l the author of the present paper to the investigation of the vari- s plans which had been proposed or tried, for transferring boats m one level to another without the loss of water which occurs in e use of locks—he found that there existed in these plans what peared to him an insuperable objection—the necessity of water- ght gates or sluices, to be opened and shut in the passage of each

boat, and the least derangement of which might not only stop the traffic of the canal, but be productive of most serious consequences. There occurred in some plans the very serious evil of the boats being transferred from their proper water bearing to a dry or partially dry cradle, causing serious risk of injury to the boat, by the strain arising from the unequal bearing.

It appeared, then, that to the successful application of any lift or method of transferring boats, two points were essential: first that the boats should float in water during transfer; and next, that there should be a total absence of gates or sluices in the main line of the canal.

To make the boats float into a caisson or tank, sunk in the water disposed of both the above points at once; and the only thing then to be sought for was the proper mechanical arrangement by which the caisson, with the boat floating in it, might be lifted out of the water at the one level, and transferred to the other level, without the loss of water, or the use of more power than is necessary to overcome the friction of the machinery.

The method by which this is proposed to be accomplished is shown in Plates 46 and 47.

The upper level of the canal is divided into two branches or arms, U U, each of a sufficient width, and carried along each side of the lower level of the canal, V, to a sufficient length, to receive an ordinary canal boat. The sides of the canal forming the upper levels may be constructed of stone and brickwork, as in ordinary locks, or of iron carried upon timber framing. The depth of each branch of the canal is sufficient to permit a boat, W, with a full load, to float over the ends of a caisson or tank, D D, that is of sufficient size to contain water enough to float a loaded boat.

Over these branches of the canal is erected a timber or iron framework, upon the top of which, at points immediately over the upper and lower branches of the canal, are fixed rails, A A, and on these rails are placed carriages, B B, containing a series of wheels, over which run the chains, C C, for lifting the caissons.

At the bottom of one of the branches of the canal, on the upper level, and of one on the lower level, are placed the iron caissons or

nks, D D, which are carried by straps, attached to cross bearers, E, and suspended by the chains at points immediately under the mework.

At one side of the framework, in two vertical grooves, is susnded the large shaft, F F, carrying the four drums, G G, on ich the suspending chains wind and unwind in the operation of sing and lowering the caissons; the two sets of chains being und on the respective drums in opposite directions, so that when caisson is raised, the other is at the same time lowered. On h end of this shaft, F, is a bearing or journal, which is grasped by eye or strap, H H, in which it can revolve; to these straps is attached end of the equilibrium connecting chains, I I, the other ends of ich are fixed to the cams, J J. These cams are keyed fast on shaft, K, and on the same shaft are also keyed two other cams, L, to which is attached, by two chains, the balance weight, M. the same shaft are keyed the large wheel, N, and two drums, O, to which are attached, on opposite sides, the two water buckets, P, for the purpose of aiding, if required, the manual power in rking the lift.

The balance weight, M, is nearly equal to the weight of the ssons in the water, when working through the shortest leverage the cams; the caissons being allowed a little weight in excess, order that they may freely sink to the bottom of the water. The ance weight, when acting through the longest leverage, (as own by the dotted lines,) is equal to balance the caissons when of the water and full of water; this weight of the caissons being *same under all circumstances*, on account of the relative discement of water, whether they contain a loaded boat or an pty boat, or are merely filled with water, without any boat. The m of the cams between these two extreme points is regulated by form and depth of the caissons.

The following is the action of the Equilibrium Lift:—Supposing loaded boats approaching the lift, one on the upper and the er on the lower level of the canal, (but the same description plies to empty boats, or to a single boat,) each boat is floated into arm of the canal, over the caisson lying at the bottom, in the

same way as into ordinary locks. The first operation of lifting is to raise both caissons out of the water, with the boats floating ir them: this is done by applying power to the series of wheels, Q which turn the shaft, K; by which operation the chains, I I, ar wound on the cams, causing the shaft, F, with the drums and suspending chains, to move down the vertical grooves in the frame work to the position shown by the dotted lines at R, and thus raisin the caissons and boats out of the water. This operation may be per formed either by manual power or by means of the water buckets P P, by turning on water from the upper level into the descendin bucket, and letting out the water, by a self-acting valve, on the bucke reaching the bottom. The varying weight of the caissons, in pro gress of being raised from the bottom to the surface, until out o the water, is allowed for, so as to preserve the equilibrium through out the operation, by the varying leverage of the balance weigh acting upon and through the four cams; so that the power has littl more than the friction of the machinery to overcome.

Having by this means lifted both caissons out of the water that one which is required to descend to the lower level is move across the bank of the canal, by means of the railway, A A, on th top of the framework, in a similar manner to an ordinary traversin crane, until it is suspended over the lower branch of the canal ready to descend, as shown by the dotted lines at S. When in this position, the wheel, T, on the end of the shaft, F, is geared to the series of motion wheels, Q, by means of a shifting clutch, at X the power is then applied, and the shaft caused to revolve, which by unwinding the chains attached to the descending caisson, and winding up the ascending one, carries them to a relative position opposite to that from which they started; and they are stopped at the proper point by the top of the cross bearers, E, coming in contact with the bottom of the chain carriage, B. The caisson which has been raised from the lower level is then moved, as before, by means of the railway, across the bank of the canal, and suspended over the upper branch; the clutch is then ungeared, the power again applied to the shaft carrying the cams with the balance weight, and the caissons are simultaneously lowered to the bottom of the canal, and the boats floated over their ends and away to their destination.

Various plans for passing boats from one level of a canal to
nother, by vertical lifts, have been proposed, and some partially
rried out in practice. In most of these, however, there is a loss
consumption of water from the upper ponds of the canal in excess
that consumed, or in diminution of that supplied, in passing the
oward or downward trade respectively. It will be obvious that
e plan above proposed occasions no waste of water; that in
ssing the upward trade the water consumed is equal to the
nnage of the ascending trade; and in the opposite direction, the
ater supplied to the upper ponds of the canal is equal to the
nnage of the descending trade; so that a weight of water equal to
e whole downward tonnage will be absolutely transferred from
e lower to the higher levels of the canal.

The difference of the levels of the two branches of a canal to
ich this Equilibrium Lift may be applied, is limited only by the
rength of materials and convenience of working.

In the present system of Locks, the amount of traffic on canals
really limited to the supply of water, and this in many cases is
ficient for the ordinary traffic; so that any reduction of the
esent rates of carriage on canals becomes hopeless under the
esent system. But by the adoption of such a system as the one
oposed, on the summit levels of canals, their capacities for traffic
ay be so increased as to enable them successfully to compete
th the Railway system, which now threatens to swamp three
urths of the canal property in the kingdom.

This Equilibrium Lift may be made single or double. In its
uble form, as shown in the drawings and model, it is estimated
at it would pass one boat up and another down in about three to
e minutes, according to the height of lift.

The value of this lift is its capacity for an almost unlimited
nount of traffic, without any expense of water, instead of incurring
e constant loss that attends the present locks, amounting to more
an 100 tons of water each time that a boat passes through. The
ormous annual expense of water to replace the loss by the locks,
many of the canals in the Midland districts, is too well known
those acquainted with their practical working to require any

observation. Supposing the proposed plan applied in several pa of the surrounding district, where there are from 16 even 30 locks situated close together, and the loss of time to eve boat in passing the series of locks is from 2½ to 5 hours, a m important saving of time would be effected; as, with one and t lifts respectively in those cases, the whole time required fo boat to pass would be only from 10 to 20 minutes.

It is of course impossible to calculate the expense of the lift the various heights, without knowing the exact position, but it considered that for a height of about twenty-one feet, or th ordinary locks, the lift would be as cheap as locks. For a l height the comparative expense would be greater; but for a grea height, within reasonable limits, the lift would be considera cheaper than locks. In cases where it might be desirable to trans the boats through a great height, they might be passed at one through a shaft into a tunnel below, at any depth that might required.

The CHAIRMAN illustrated the action of the lift by a large wor ing model. He observed, that in former plans for lifts there w danger of the boat suddenly striking the surface of the wat with the momentum of descending, but that was not possible the present plan: the boat was necessarily stopped before reac ing the surface of the water, and it was then lowered into t water gradually by a second movement. The boat was complete guided into its situation over the caisson; and there was danger of the boat going wrong in working the lift; even if boat happened to be caught by the top of the caisson in liftin no damage could be done, as the man would not be able to l it, having only power enough to overcome the friction of t apparatus. In this plan, there was no risk of loss of water fro carelessness or accident; but, in some plans, where the end of t canal was closed by a sluice, a boat striking the end, by comi

too fast, might do serious injury, and risk the loss of the water
hat section of the canal.

Mr. MABSON enquired what would be the probable expense of
lift?

The CHAIRMAN replied, that the expense of locks might be
imated at about £1,000 each; and for a height of three locks,
21 feet, the cost would be about £3,000, and the lift would
about the same; but the higher they went with the locks, the
ter would his plan be suited, and the saving proportionally
ater, as most of the expense of the extra locks would be saved.
observed that his object was to show the applicability of
lift, leaving those interested in canals to judge of its ad-
ntages.

A vote of thanks was passed to the CHAIRMAN for his paper,
l the discussion adjourned.

The following paper, by Mr. S. H. BLACKWELL, of Dudley,
s then read:—

ON AN IMPROVED MINER'S SAFETY LAMP.

The Improved Safety Lamp, which is the subject of the present
per, is the invention of Mons. F. Eloin, Mining Engineer, of
lgium.

A visitor to the Exhibition of 1851, he brought over this Lamp
h him, for the purpose of introducing it to the notice of the
ncipal mine viewers of this country; and it thus becomes of
litional interest, as being one of those contributions of the
ctical science of the Continent to our own manufactures which
e already resulted from the Exhibition, and which will doubtless
l much to our own future progress.

Important as was the discovery by Sir Humphrey Davy, of the
perty possessed by thin wire gauze to prevent the passage of

flame, (and it is scarcely possible to over-estimate the
discovery,) yet it could hardly be expected that the d
arrangement embodying this principle could be a
perfect. Attempts to improve the structure of the
Lamp have therefore been numerous, but few of the
generally adopted, and in most of our collieries the
of lamp is still used.

The principal defects of the common Davy Lamp a

First;—Deficient light, rendering the collier always
use it, unless compelled by the presence of a high
atmosphere.

Second ;—Liability of injury to the gauze of the cy
by a blow from a pike, a fall to the ground, or otherwi

Third ;—The possibility of a current of explosiv
being carried through the gauze cylinder, either by t
of the lamp in the hand of a person when walking, o
exposed to the powerful *blowers of gas*, which are som
off with great force.

Fourth ;—The heating to redness of the gauze,
plosions actually take place, not from the passage of f
the gauze, but by the actual contact of the explosive
with the heated wire. This danger is often increase
sence of small particles of coal dust, which, floatin
of the mine, attach themselves to the gauze ; and a
deposit of *soot on the gauze*, arising from the imperfect
of the oil, which in the common Davy Lamp alway
dense column of smoke.

In the improved Lamp of M. Eloin (shown in Fig
all these defects are obviated.

First ;—in reference to light. The cylinder, A I
flame, is closed, and air admitted only *below the flam*
narrow breadth of gauze, C ; but the air which is
brought into actual contact with the flame, by the
the cap, D, on the principle of the *solar lamp ;* and thus
bustion is produced, giving off light equal to at leas
ordinary Davy Lamps. The light produced is one whi

uld prefer to that of any candle, from its greater intensity. om the perfect combustion of the oil, no *smoke* whatever is en off.

Second;—As to the liability of injury to the gauze. This is viated by using, first, a strong short cylinder of glass, A, through ich the light passes, capped above the flame with a brass or iron inder, B, which cannot be injured, except by actual violence. might be supposed that the glass portion of the cylinder would liable to accident, but in practice this is not found to be the se: bound, at top and bottom, by a strong brass ring, if it were en to crack, either from a blow, or from unequal expansion by at, no danger would result, as the pieces into which it would be parated would still be held together with the brass beadings.

Third;—The closed nature of the cylinder entirely prevents the ssage of an explosive atmosphere into the lamp, by any current air; no swinging of the lamp causes any action on the flame; d no blower of gas can blow into the flame, in consequence the protection of the cylinder.

Fourth;—All danger by the heating to redness of the wire uze is entirely removed.

In addition to the entire removal of the defects of the common avy Lamp, the Lamp of M. Eloin possesses, from its structure, me peculiarities that render it much safer.

The air which enters through the narrow breadth of wire gauze, *low the flame*, being only such as is necessary to support the flame f the wick, and the combustion being of so perfect a character, hat portion of the cylinder which is above the flame must always e filled with the products of combustion, and never with an explosive atmosphere. In the ordinary Davy Lamp there must always e a tendency in the surrounding atmosphere to rush through the vire gauze into the lamp, and to fill it, more or less, with the tmosphere of the mine, whatever that may be. In M. Eloin's amp the contents of the cylinder above the flame must always be he products of combustion. This is clearly seen by the flame being extinguished whenever the general upward current is by any neans reversed. So confident is M. Eloin of the action of his

lamp in this respect, from his experience in the Belgian mines, that he has placed a very coarse wire gauze over the top of the lamp, simply for the purpose of preventing any particles of coal or dirt from entering, but of a width that would readily allow the passage of flame, if any flame could be supported in the upper part of the cylinder.

The weight of the lamp (always an important consideration where it has to be carried for any length of time in the hand) is not at all objectionable.

It is not expensive in its structure. A lamp as highly finished as that now before the meeting costs in Belgium about 7 francs.

The power of perceiving the presence of gas, by the ordinary elongation of the flame, is fully equal in *this* lamp to that of the ordinary *Davy* lamp.

A conical brass shade, E, is attached to, and made to slide upon the rods surrounding the glass portion of the cylinder, by which the light can be directed downwards if wished, so as to throw the light over the floor of the mine, when the shade is moved up, as shown by the dotted lines at F.

Combining, then, as this Lamp undoubtedly does, all the advantages, and, at the same time, obviating the more important defects of the ordinary Davy Lamp, the author of the present paper cannot but think that it must ultimately come into general use; and that great praise is due to its inventor, M. Eloin, for the liberality with which he has thrown it open to the English mining public without limiting its use by any patent or other restriction. He knows from the inventor personally, that nothing will give him greater pleasure than to hear of its general adoption in our collieries and he cannot but regard its introduction amongst us as a good omen of the results which, we may hope, will arise hereafter from the more cordial intercourse between the practical science of England and the Continent, arising out of the Exhibition of 1851.

Mr. Blackwell exhibited one of the improved lamps, and ordinary Davy lamp, both lighted, and said he had taken cial care to trim the old lamp well, but the improved lamp e five or six times the light; and from the perfect combustion the oil, no smoke was thrown out, whilst in the other lamp re was a great quantity of smoke. He observed that the glass ld not be injured, except by actual violence, and that with culty. He had that morning dropped the lamp from some ght upon a hard stone pavement, and it remained uninjured. knew of cases that had occurred, where the wire gauze of the inary lamp, or perhaps the particles of coal dust in the hes of the gauze, had become so intensely heated as to in- ne the surrounding gas, even from the circumstance of the p lying inclined, so that the flame heated the gauze on one ; but such accidents were effectually prevented with the new p.

Mr. Clift recollected seeing a lamp that was brought out eral years ago, which he thought bore a great resemblance to Eloin's lamp. It was, he believed, invented by Mr. Roberts, Bilston, the original inventor of the solar lamp; it was on the r principle, and so far similar to M. Eloin's lamp, but it had ass cylinder the whole length of the lamp; it was first made both a glass and a gauze cylinder, but afterwards glass only used.

Mr. Blackwell believed that he had seen Mr. Roberts's lamp, he was not fully acquainted with it. The long glass cylinder ld be a great objection, and very liable to be broken and cause losion. The glass cylinder of the lamp now introduced was he thought, at all objectionable; it was very strong and t, and even if many cracks were produced, it would still be nd together by the brass rims at the top and bottom.

The Chairman observed, there must, he thought, have been e particular objection to Mr. Roberts's lamp, or it would have n more generally used. The lamp of M. Eloin certainly gave

a very superior light to the other, and he thought it was also safer. A crack in the glass would be visible and show itself, but it would not in the gauze of the ordinary lamp.

Mr. Clift said there could be no question that the lamp of M. Eloin was much better and safer than the Davy lamp, as there was no wire gauze to heat, and endanger an explosion of gas. It was both safer, and gave a much better light. He supposed that the objection to the use of the lamp of Mr. Roberts was, the great liability for the long glass cylinder to be broken by the men, for he did not hear that it had ever come into general use.

Mr. Blackwell observed that he would be glad to make a comparison before a future meeting between the lamp of M. Eloin and any other safety lamps in use in the mining districts.

A vote of thanks was passed to Mr. Blackwell for his paper.

The Chairman announced that the Ballot Lists had been opened, and the following new Members, &c., were duly elected:

Members:

Peter W. Barlow, London.
William H. Barlow, Derby.
Edward Dixon, London.
Henry Johns, Smethwick.
Thomas Robinson, Brierley Hill.

Honorary Member:

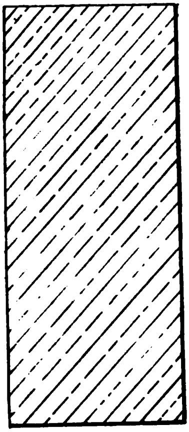
John Douglas Payne, Walsall.

The Meeting then terminated.

BIRMINGHAM: PRINTED AT M. BILLING'S STEAM-PRESS OFFICES, NEWHALL STREET.

Sections of Waggon Sole-Bars.

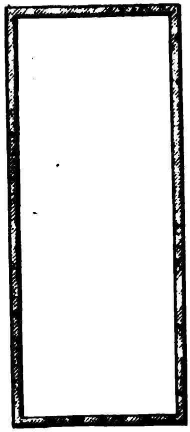
1.



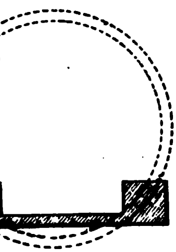
Present Oak Sole-bar 321 lbs weight.

Oak 49½ In. area

Fig: 2.

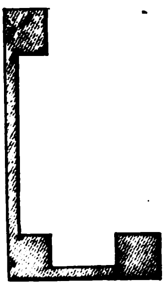


Iron 5 In. area.



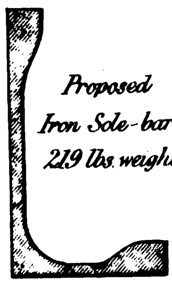
...on 5 In. area

Fig. 4



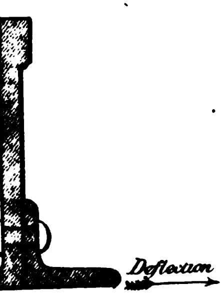
Iron 5 In. area

Fig. 5



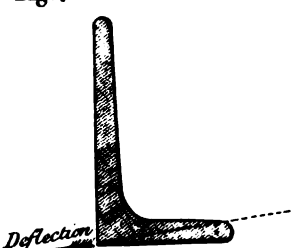
Proposed Iron Sole-bar 219 lbs. weight

Iron 5 In. area



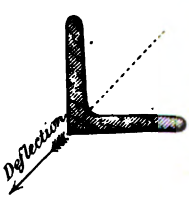
6½ In area

Fig. 7

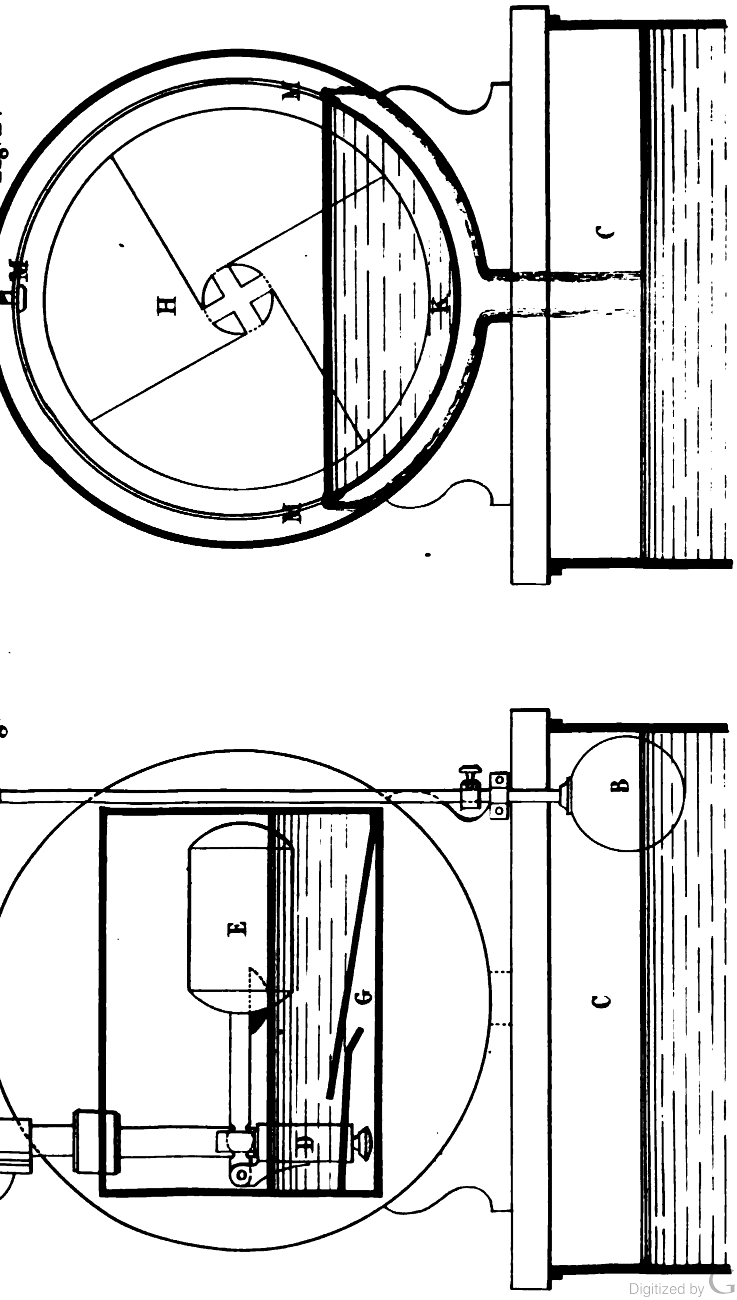


Iron 5½ In. area

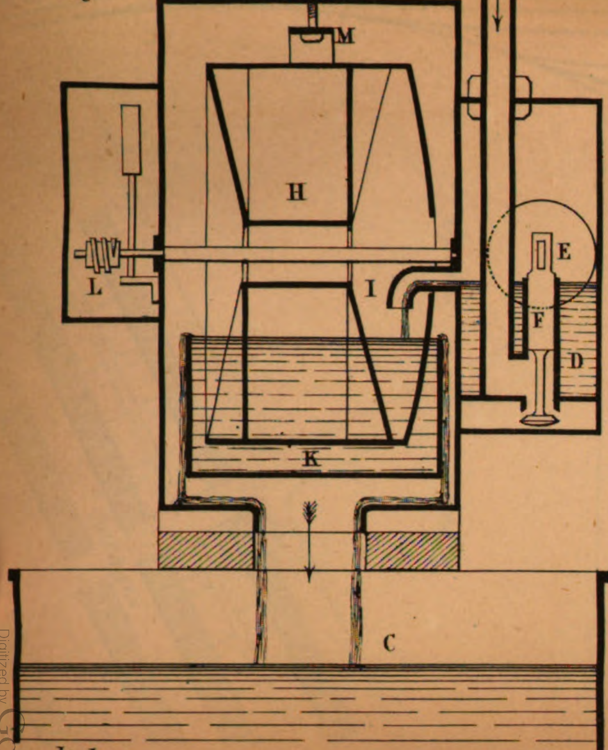
Fig. 8.



WATER METER

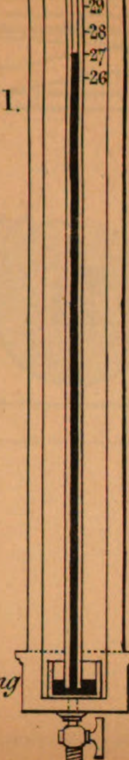


Scale 1/16th size



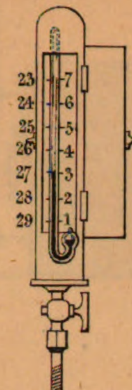
Scale 1/6th size

Fig 1.



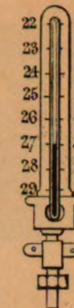
Long Gauge

Fig. 2



Short Gauge

Fig. 3.

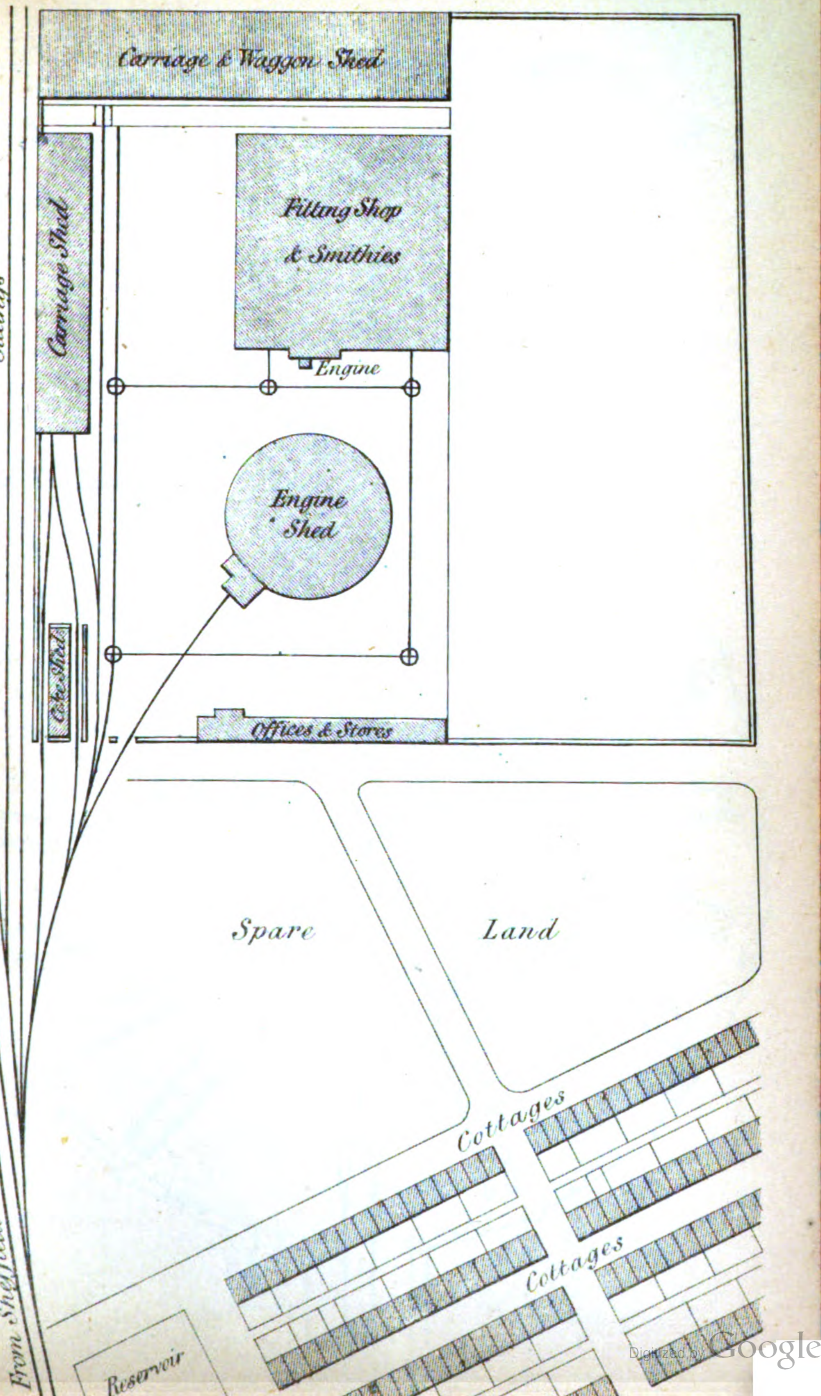


Improved Gauge

Scale 1/8th size.

Plate 20.

Manchester Sheffield and Lincolnshire Railway



LOCOMOTIVE WORKS

Manchester, Sheffield & Lincolnshire Railway

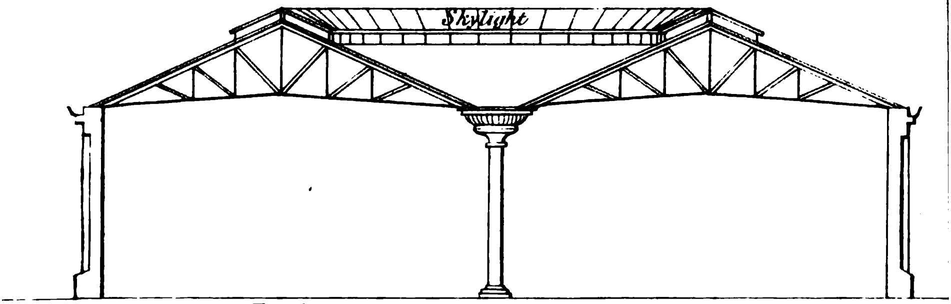
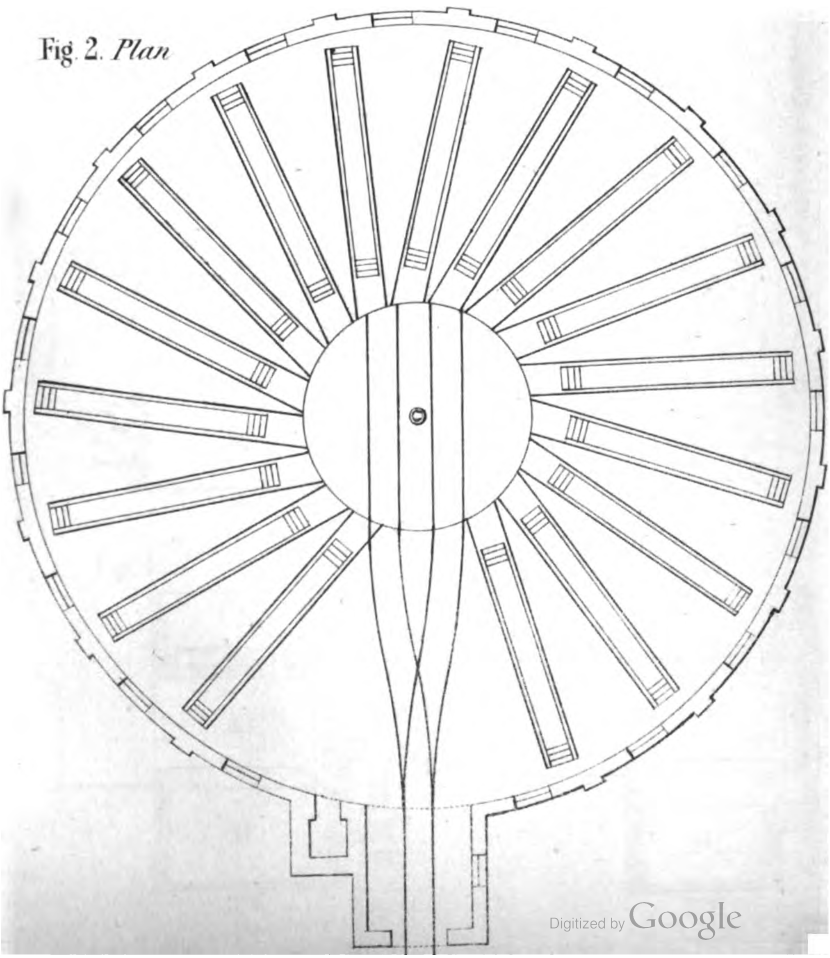


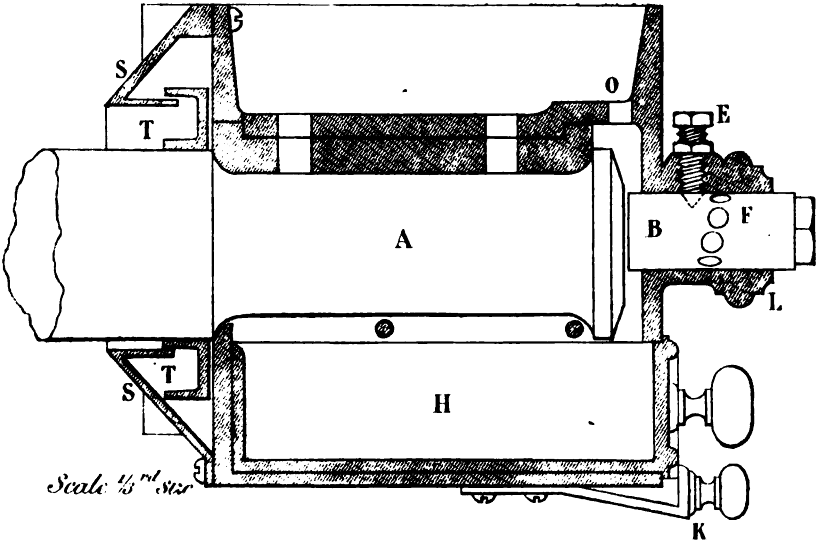
Fig 1. *Section of Engine Shed*

Fig. 2. *Plan*



IMPROVED AXLE BOX.

Fig. 1.



Scale 1/3rd size

Fig. 3.

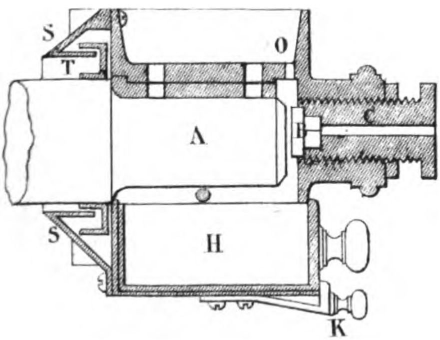


Fig. 2.

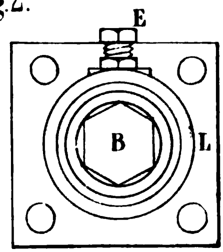


Fig. 4.

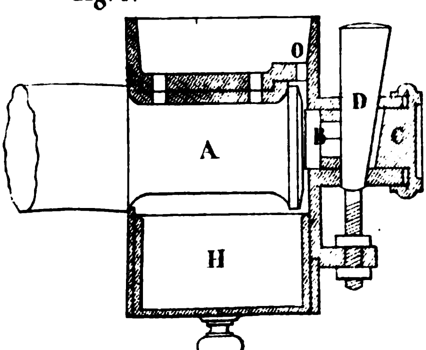
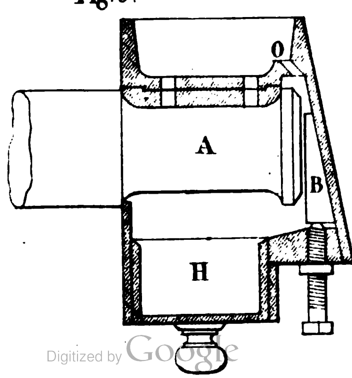


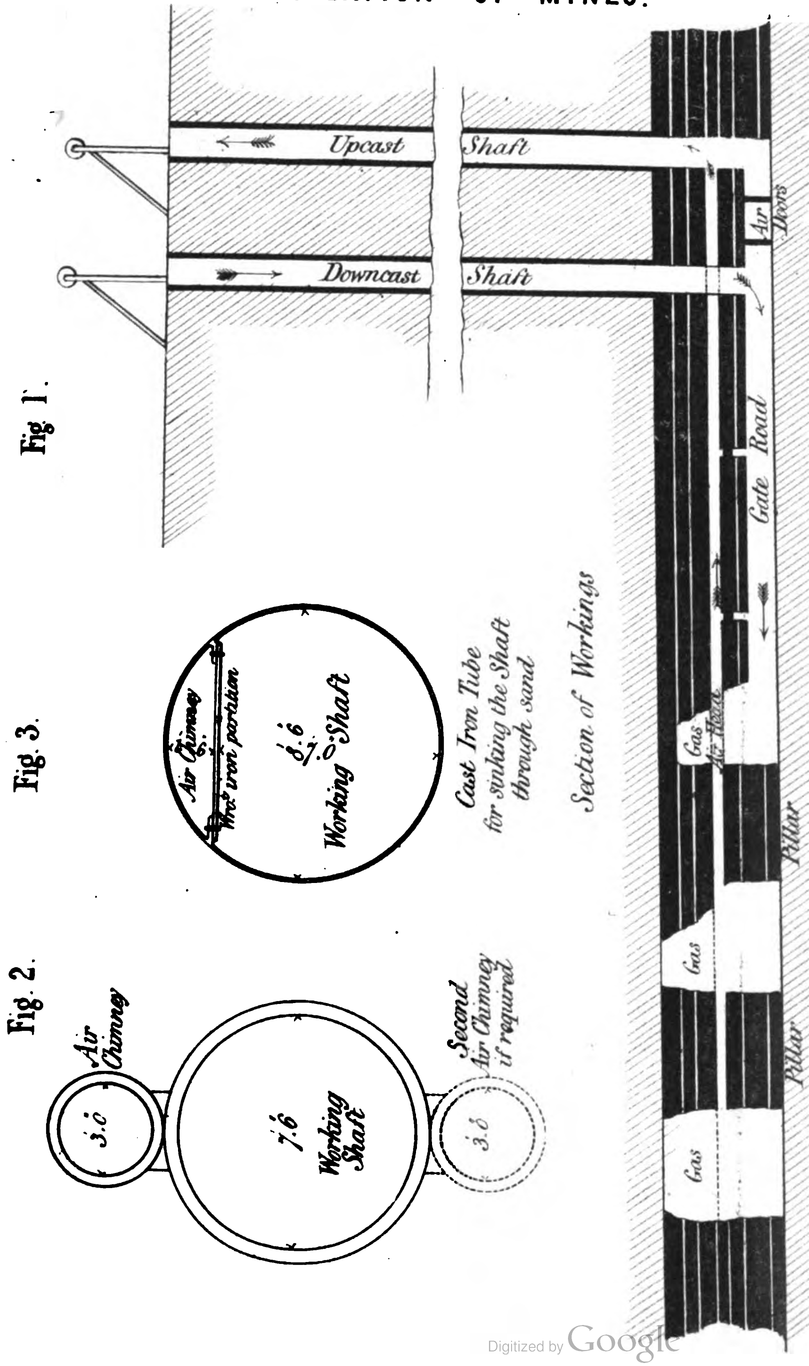
Fig. 5.



Scale 1/4th size

Plate 24.

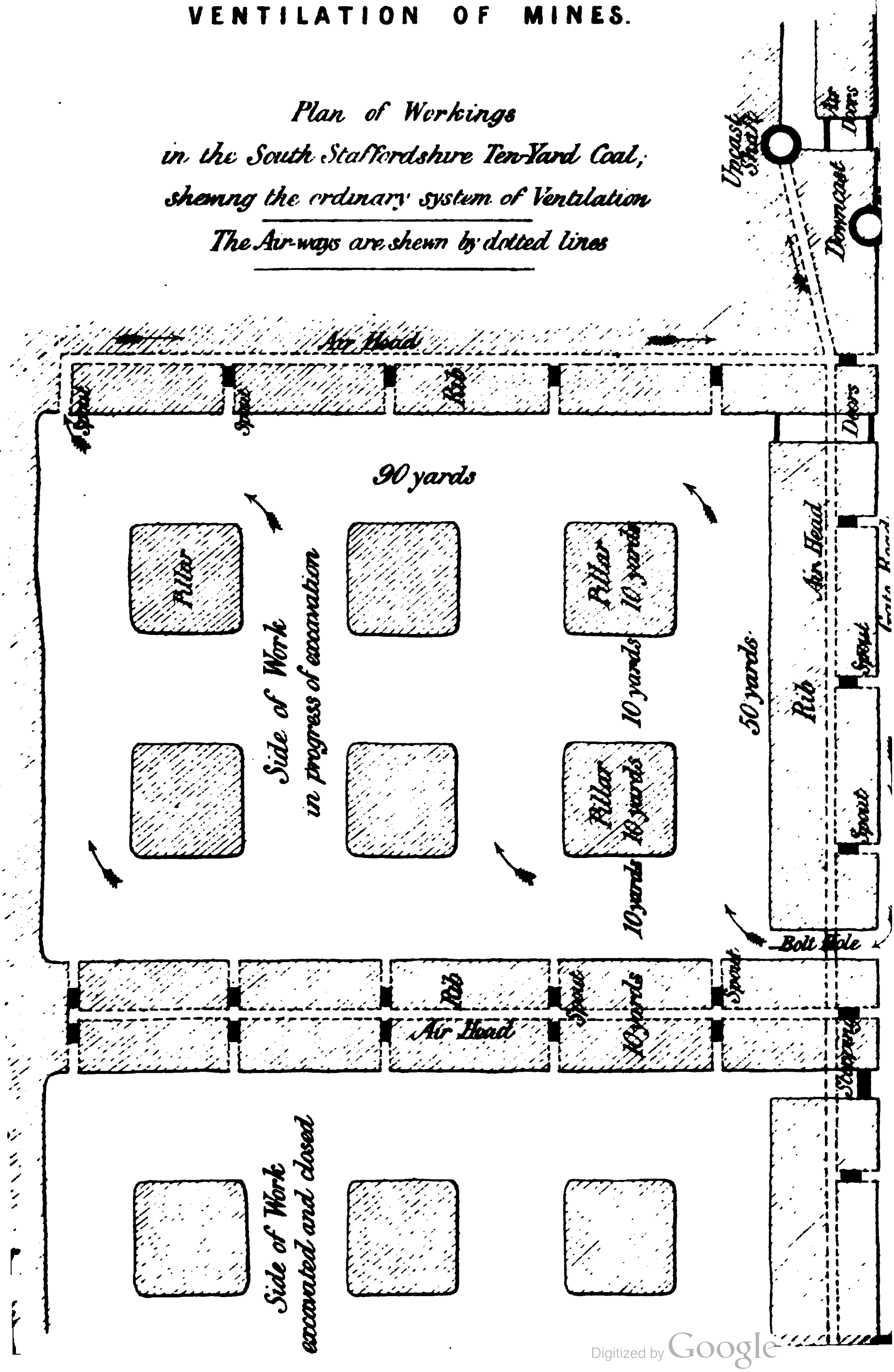
VENTILATION OF MINES.



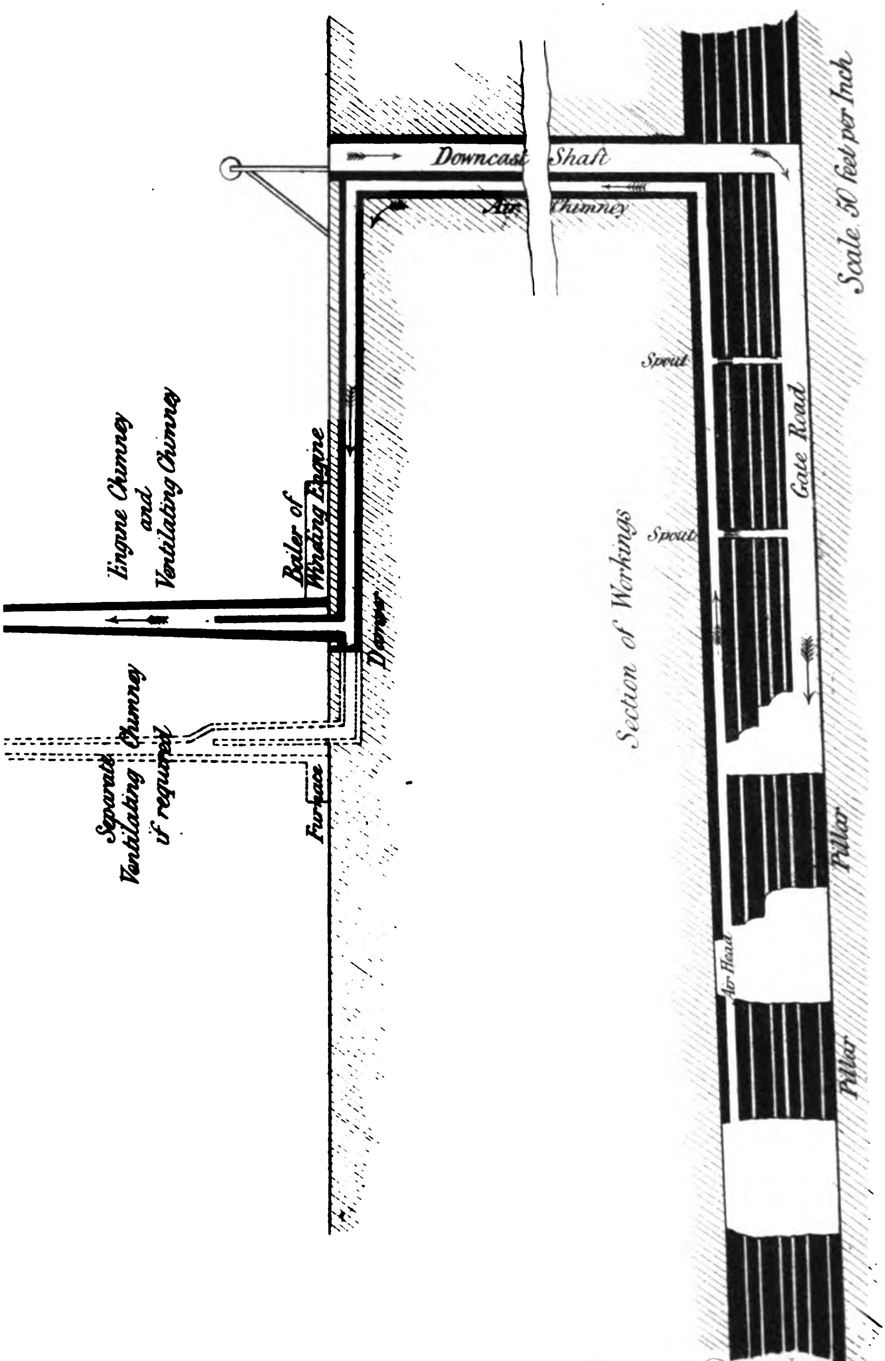
VENTILATION OF MINES.

Plan of Workings
in the South Staffordshire Ten-Yard Coal;
shewing the ordinary system of Ventilation

The Air-ways are shewn by dotted lines



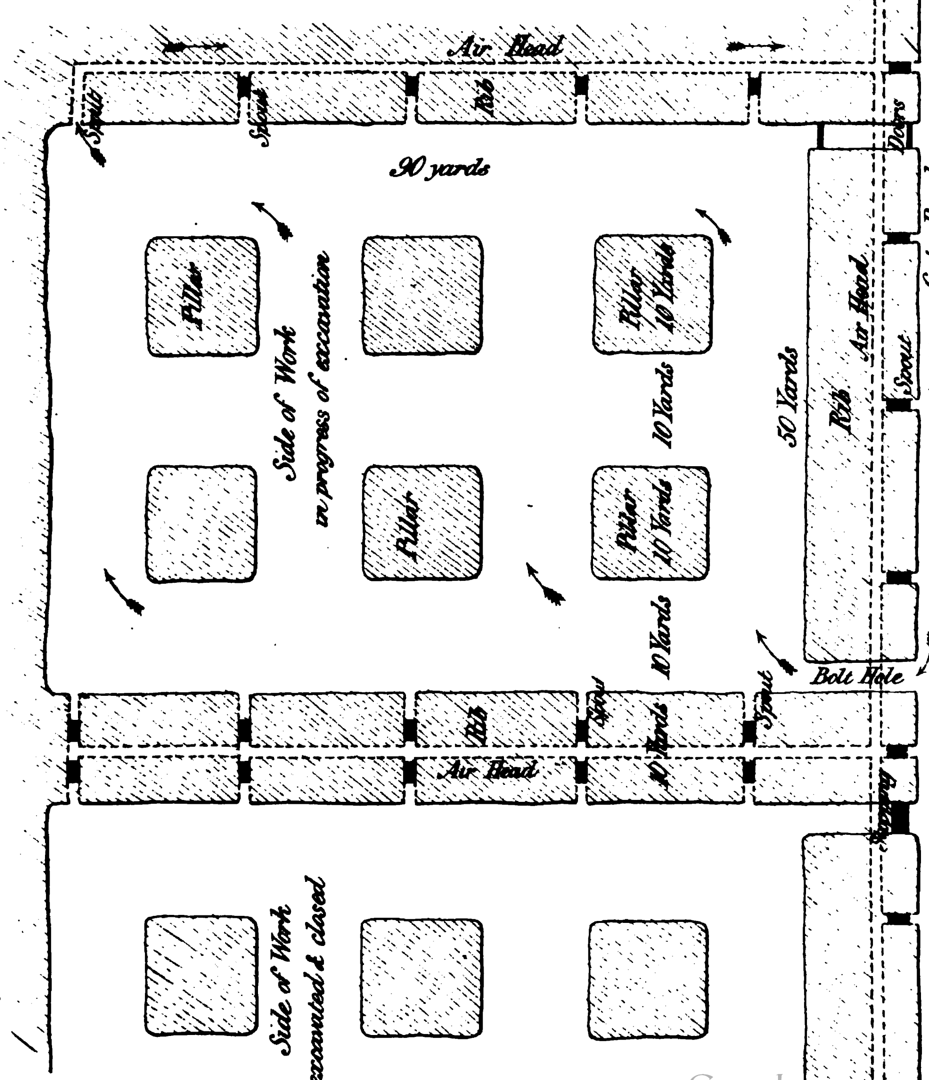
VENTILATION OF MINES



VENTILATION OF MINES.

Plan of Workings
in the South Staffordshire Ten-Yard Coal
Shewing the improved system of Ventilation

The Air-ways are shewn by dotted lines



BLOOMING MACHINE.

Fig. 1.

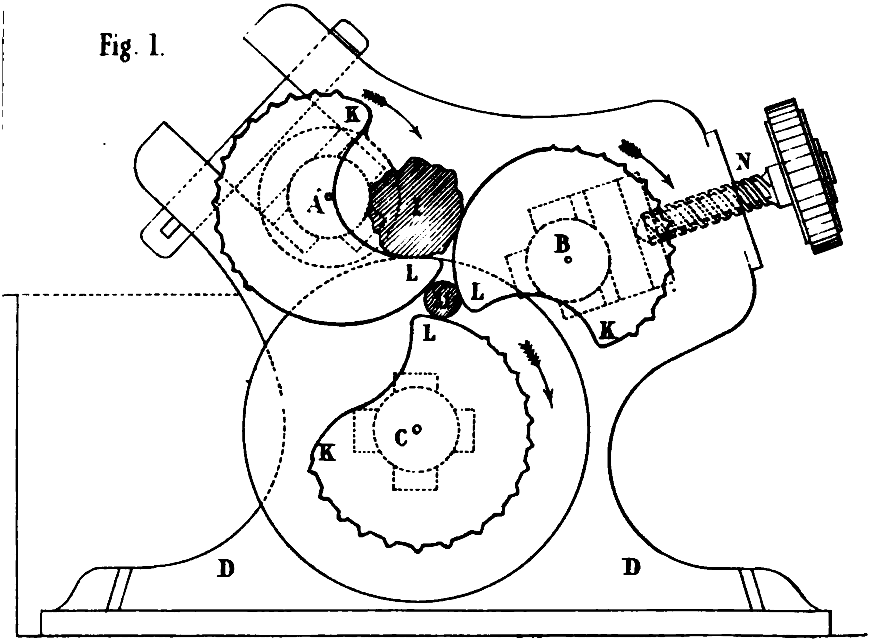
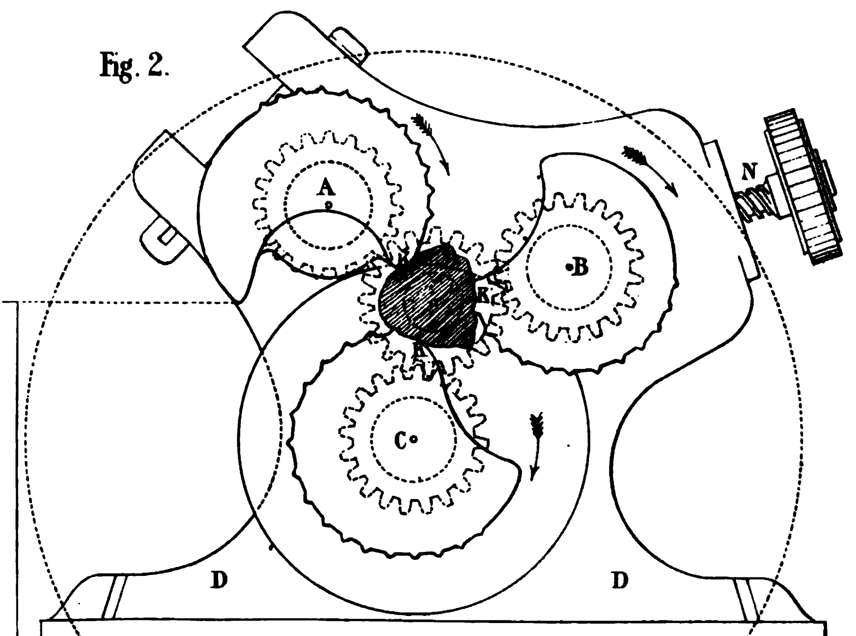


Fig. 2.

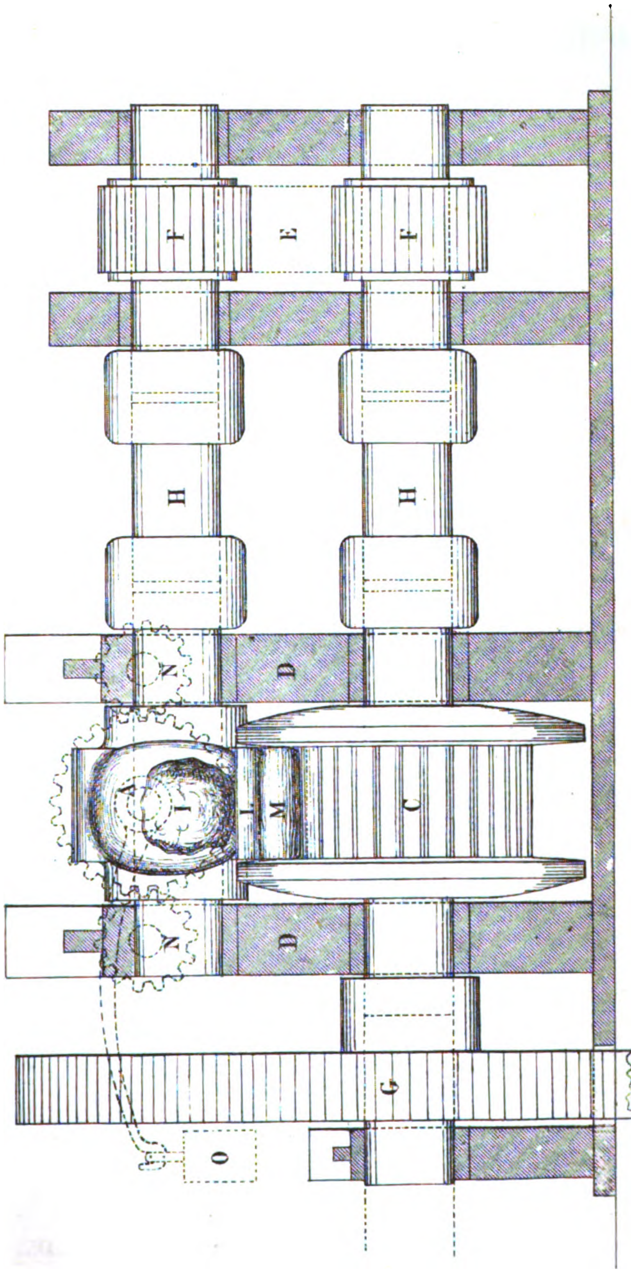


Scale_1/26th size

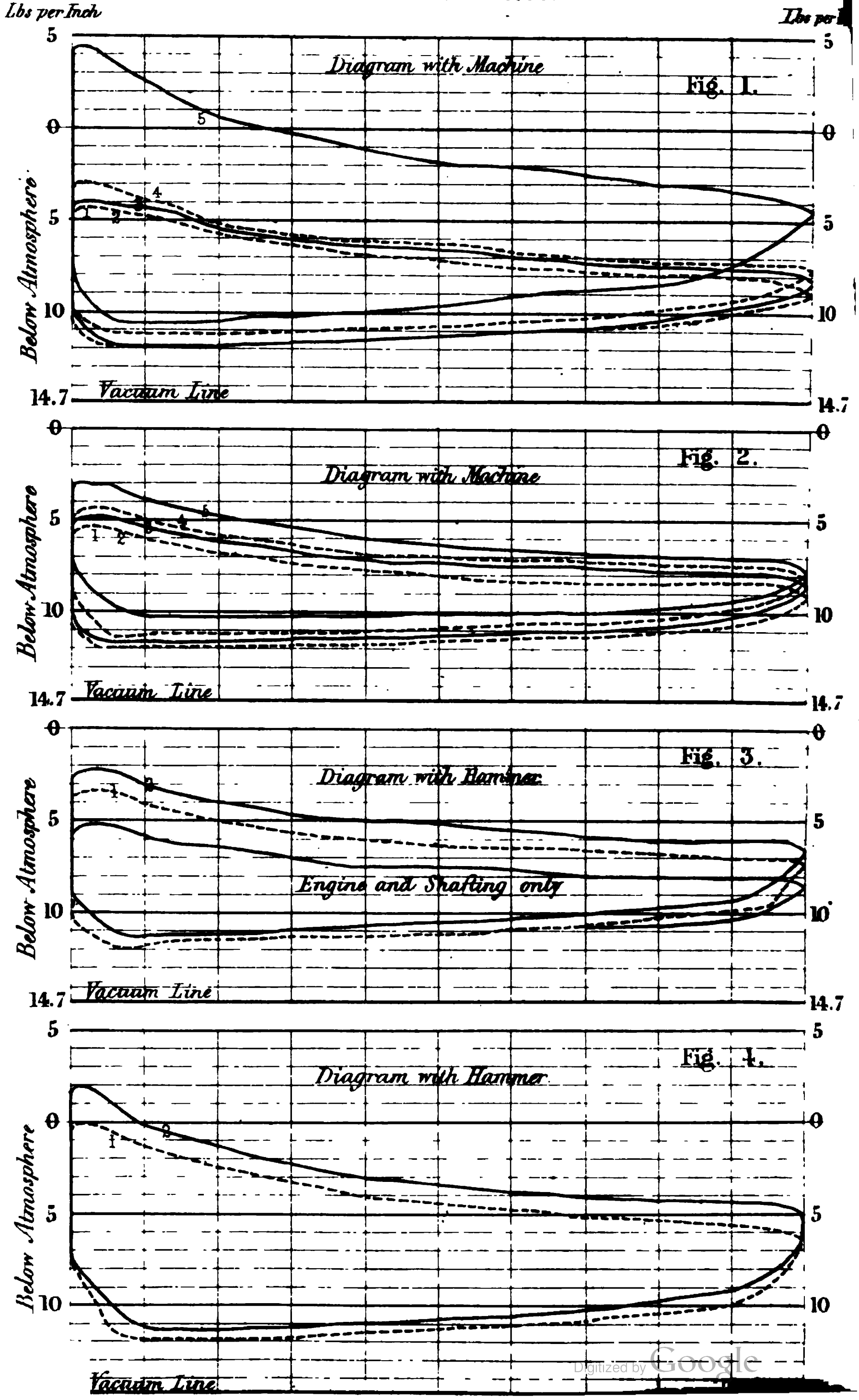
Plate

BLOOMING MACHINE.

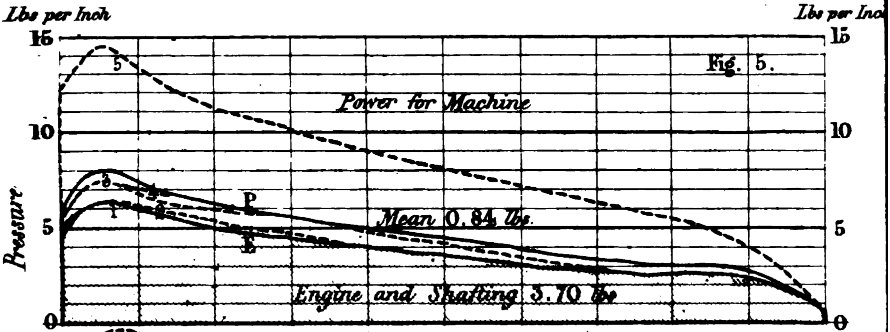
Fig. 3

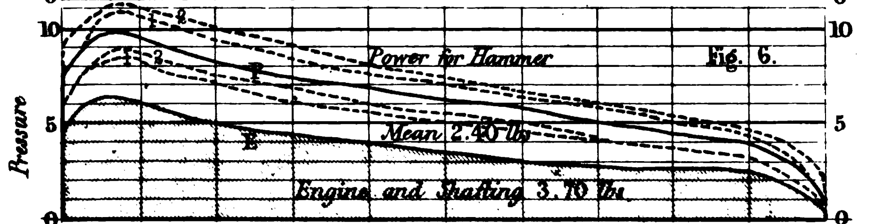


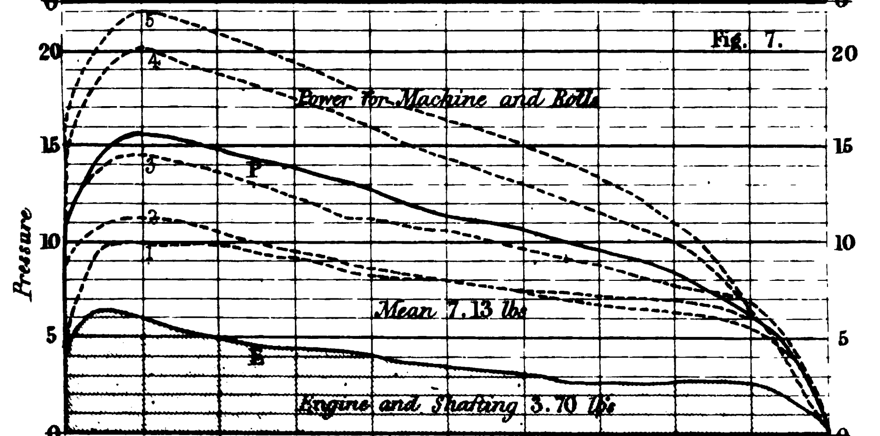
BLOOMING IRON

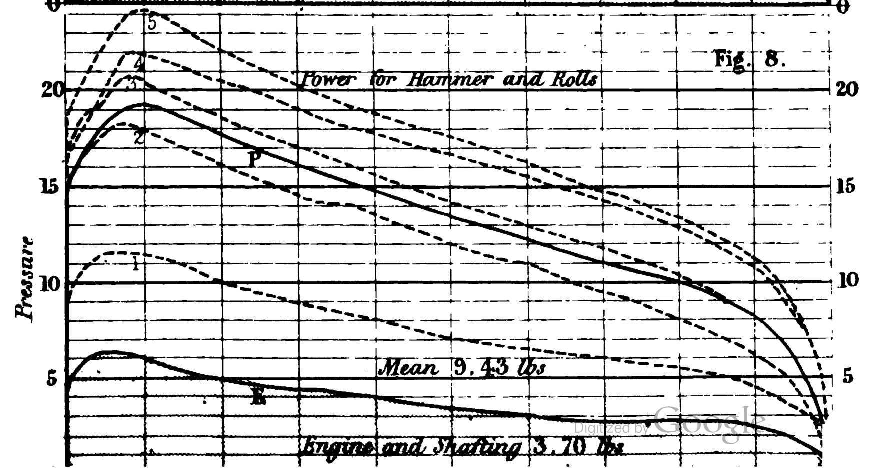


BLOOMING IRON









BLOOMING IRON.

Fig. 1. *Section of a defective Bloom from the Hammer, shewing a lap and a hollow containing cinder.*

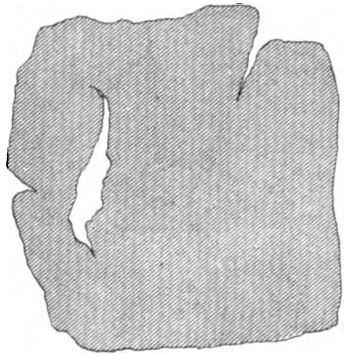


Fig 2. *Section of an ordinary Bloom from the Hammer.*

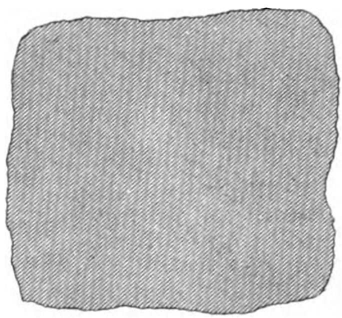
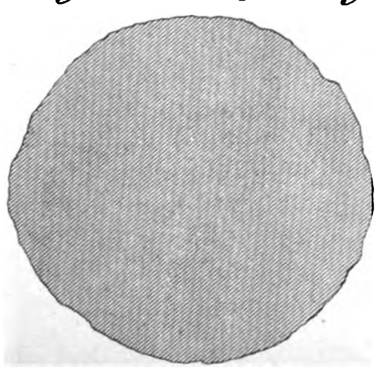


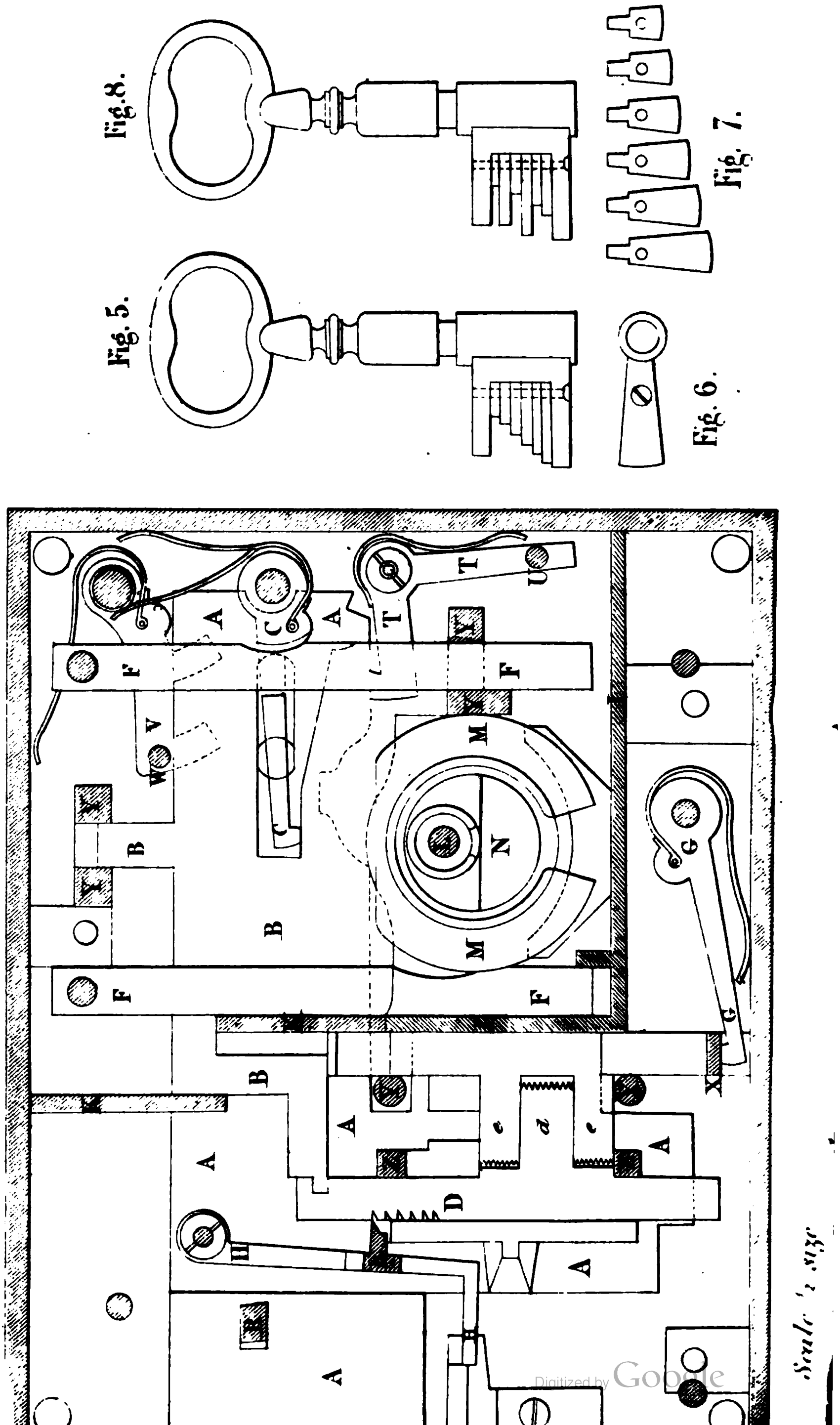
Fig. 3. *Section of an ordinary Bloom from the Machine*



Scale 1/8 size.

Pl. 33.

NEWELLS PATENT LOCK.



Plan shewing the Bolt locked & the Detector plate & Cover removed.

Fig. 2

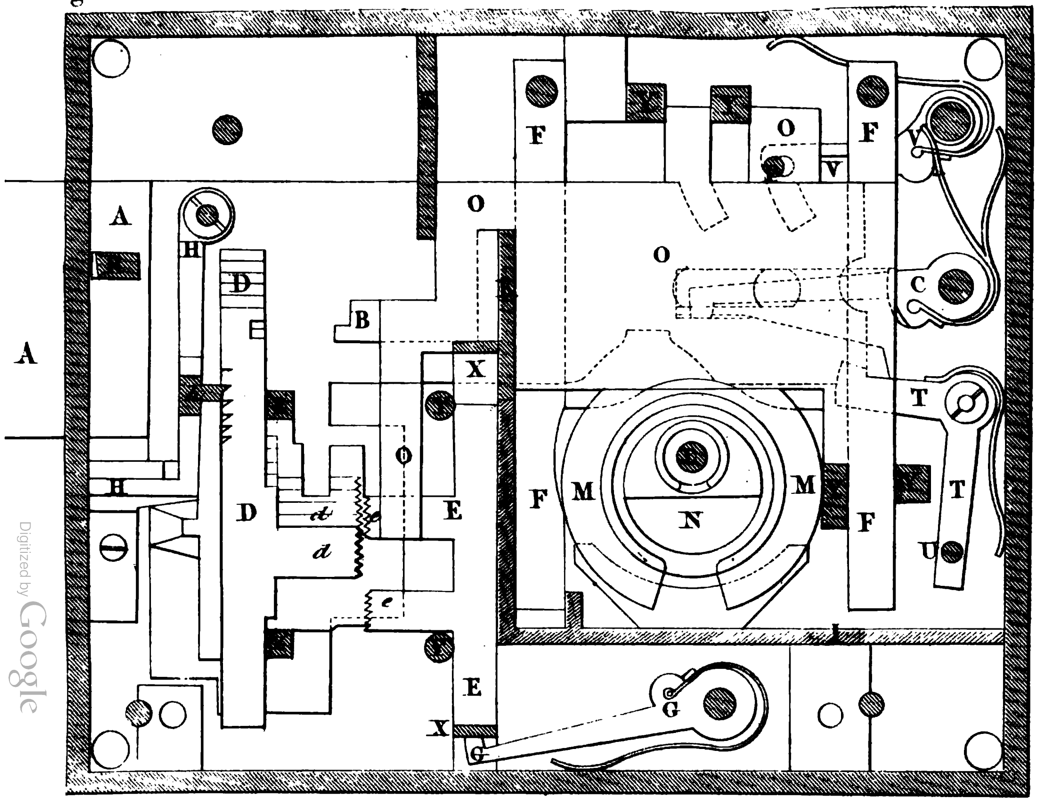


Fig. 10.

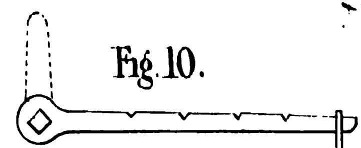
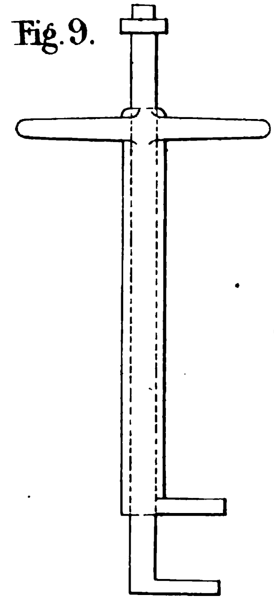


Fig. 9.



NEWELL'S PATENT LOCK.

Fig. 4.

Section through the keyhole.

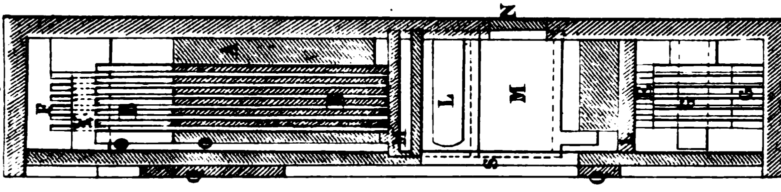
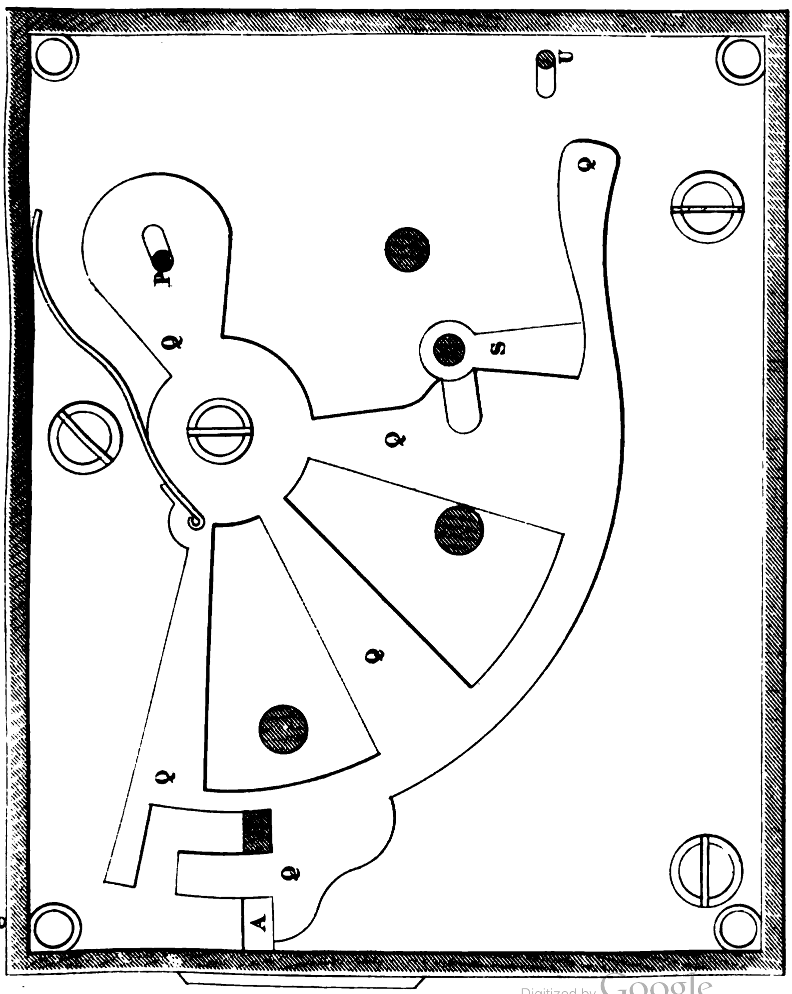


Fig. 3.

Plan showing the Detector Plate & Cover.



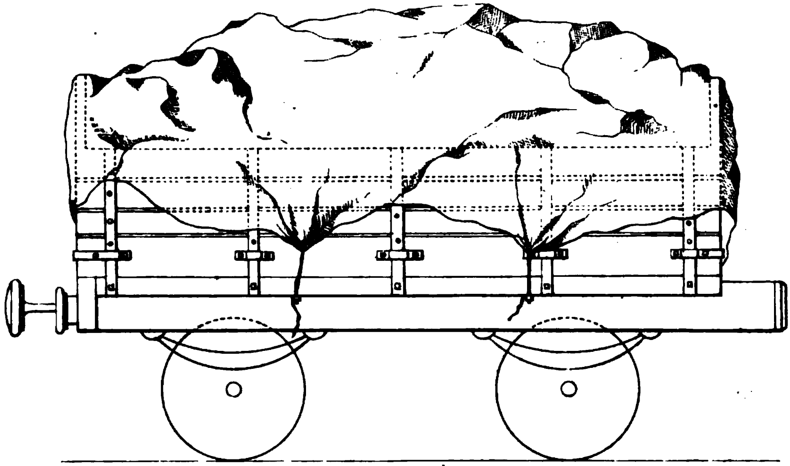


Fig. 1. *Ordinary open Goods Waggon.*

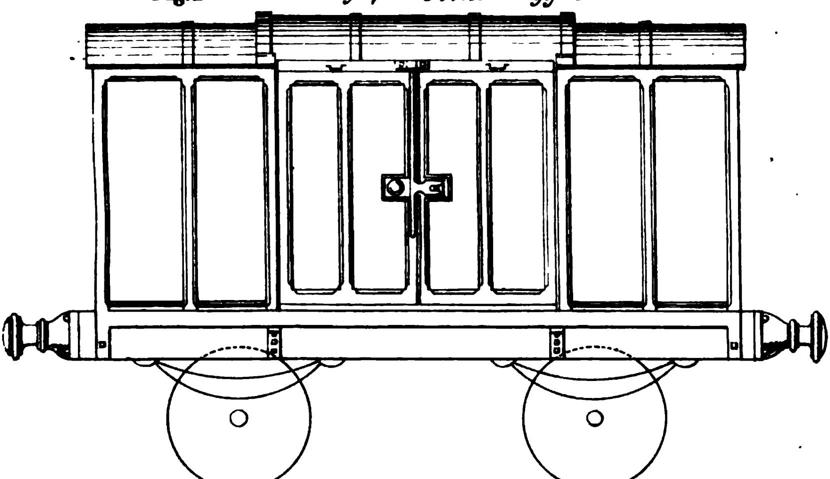
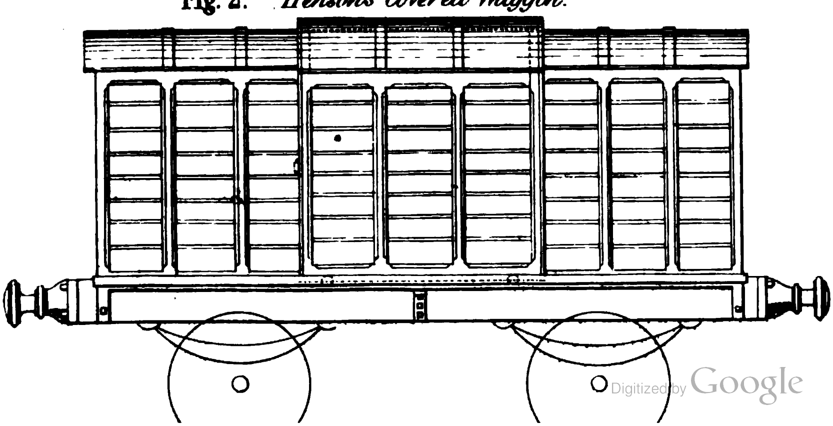


Fig. 2. *Henson's Covered Waggon.*



RAILWAY WAGGONS.

Henson's Covered Goods Waggon.

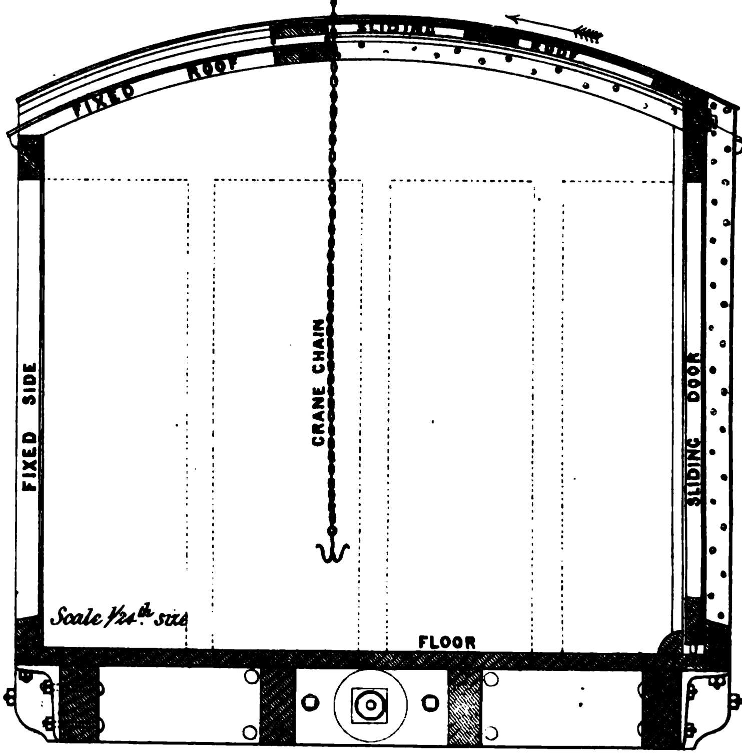


Fig 4. *Transverse Section of the Body*

Fig. 5. *Sliding Door at the side*

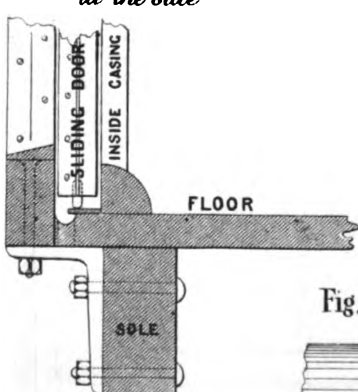


Fig. 6. *Sliding Door in the Roof*

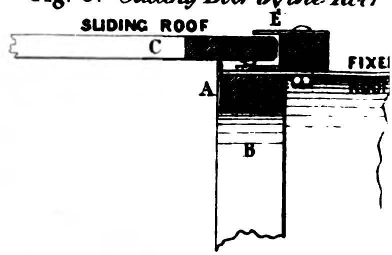
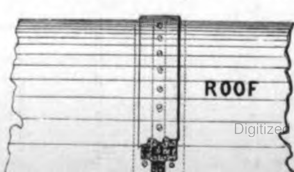


Fig. 7. *Covering of the Roof*



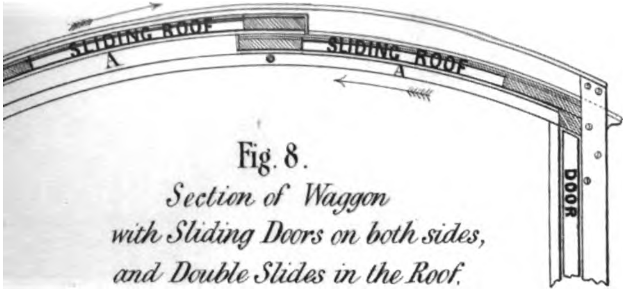


Fig. 8.
Section of Waggon with Sliding Doors on both sides, and Double Slides in the Roof.

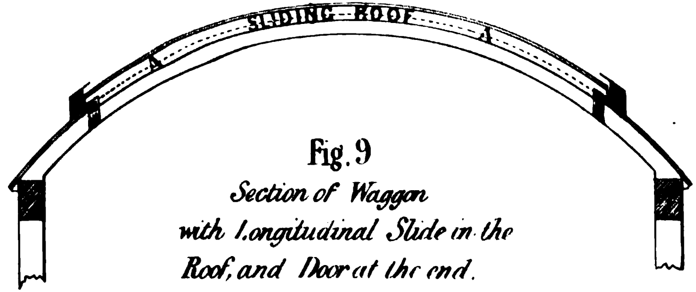


Fig. 9
Section of Waggon with Longitudinal Slide in the Roof, and Door at the end.

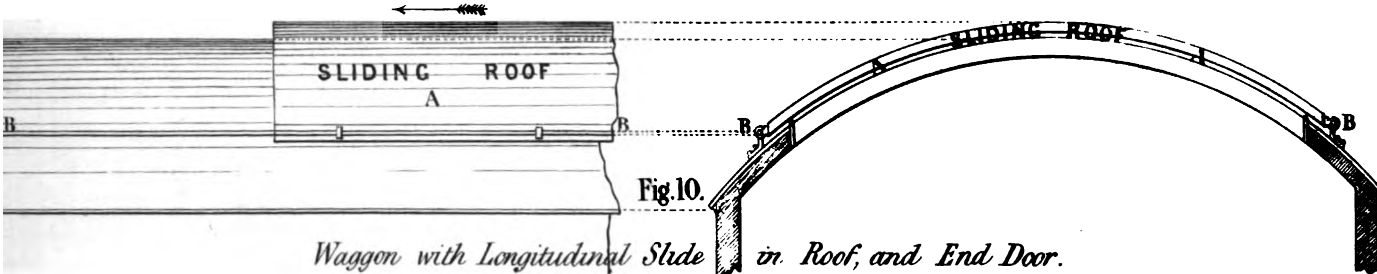


Fig. 10.
Waggon with Longitudinal Slide in Roof, and End Door.

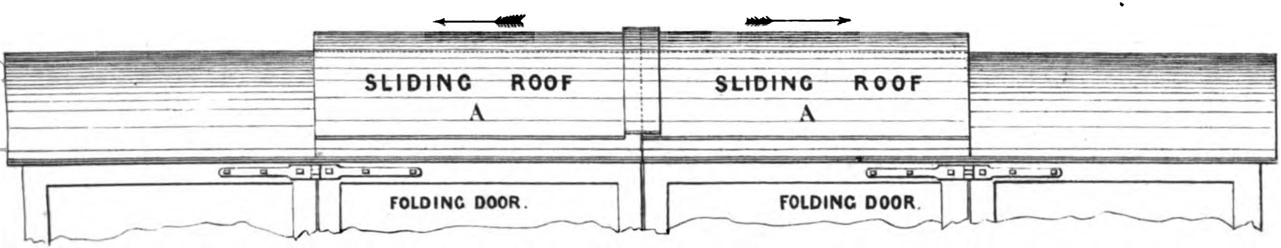


Fig. 11. *Waggon with Double Slides in Roof, and Folding Doors.*

Fig 2. Regenerative Condenser for 8 Horse Low Pressure Engine.

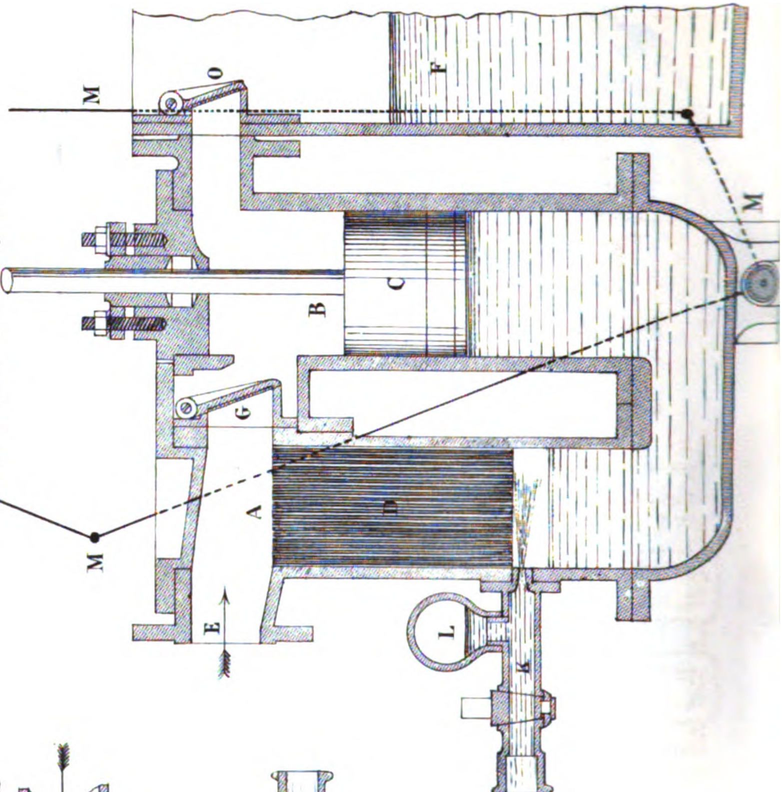
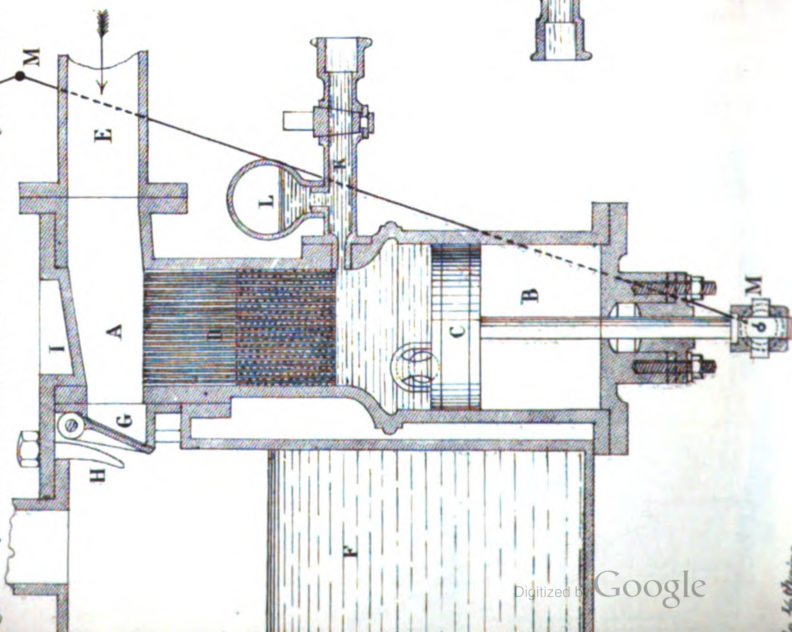


Fig. 1 Regenerative Condenser for 10 Horse High Pressure Engine.



...le 1/8th size

REGENERATIVE CONDENSER.

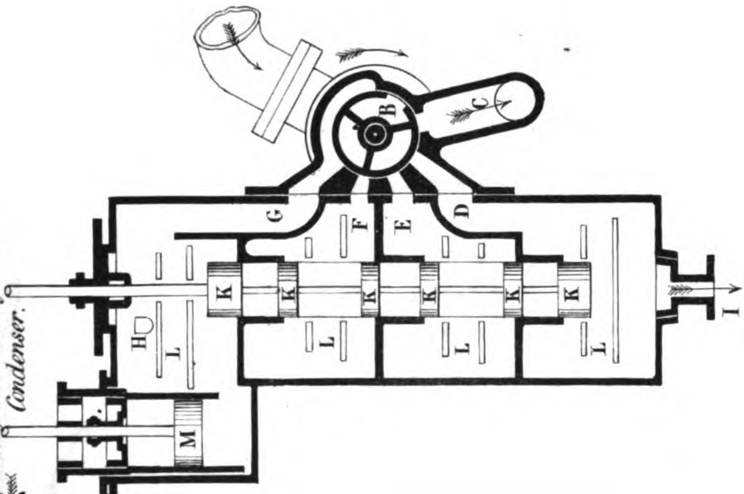


Fig. 6. Regenerative Injection Condenser.

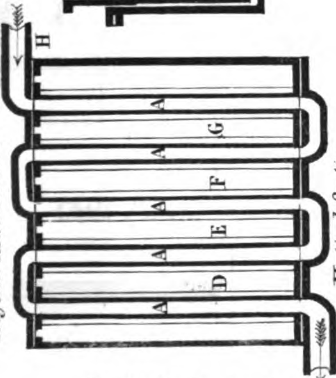


Fig. 4. Regenerative Surface Condenser. Vertical Section.

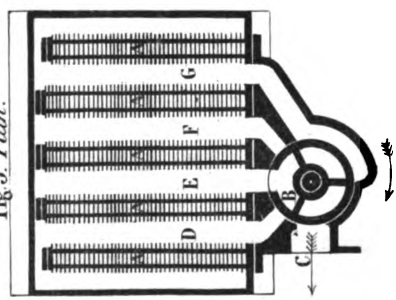


Fig. 5. Plan.

Scale 1/6th size

Fig. 3. Indicator Diagram from High Pressure Engine.

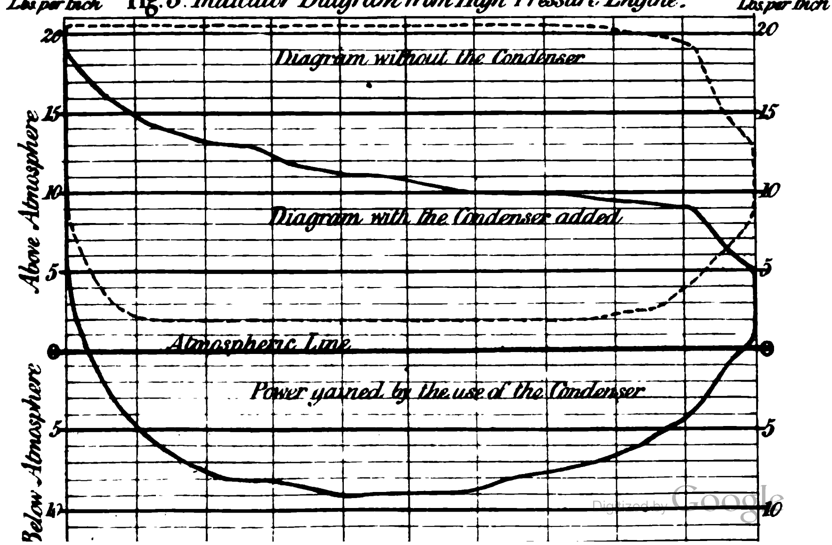


Fig. 1. *Section of Moulding Box.*

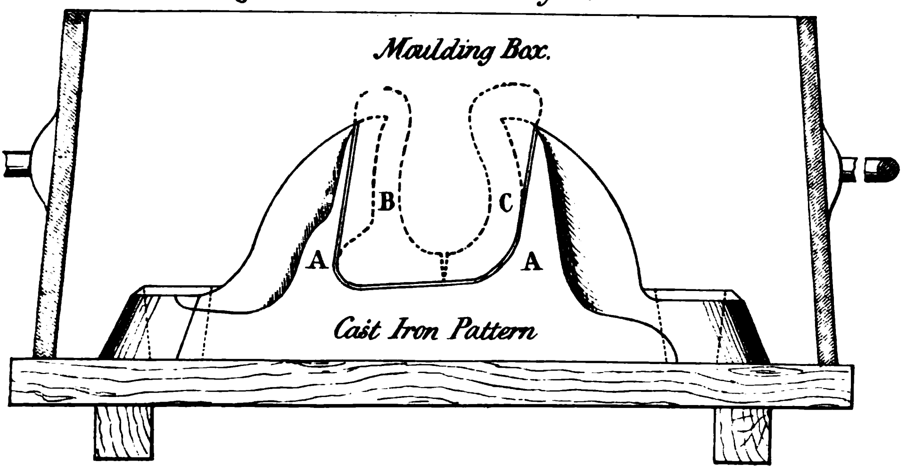


Fig 2. *Chill Plate.*

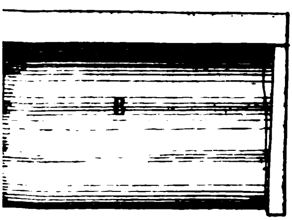


Fig. 4. *Section of Chill Plates.*

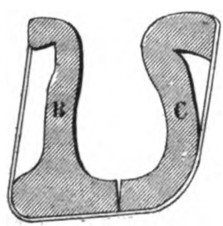


Fig. 3. *Chill Plate.*

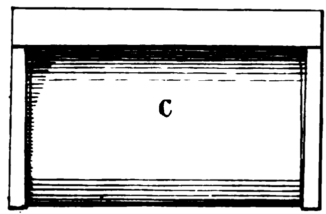


Fig. 5. *Finished Chair.*

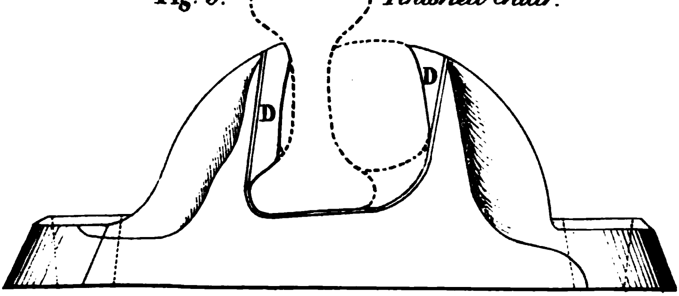


Plate 42.

SHIPTON'S PENDULOUS ENGINE.

Fig. 1

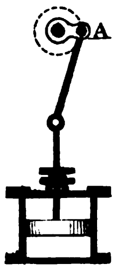


Fig. 2

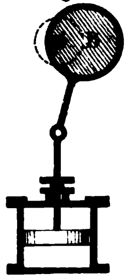


Fig. 3.

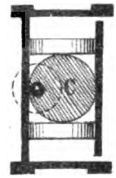


Fig. 4

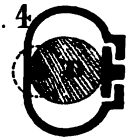
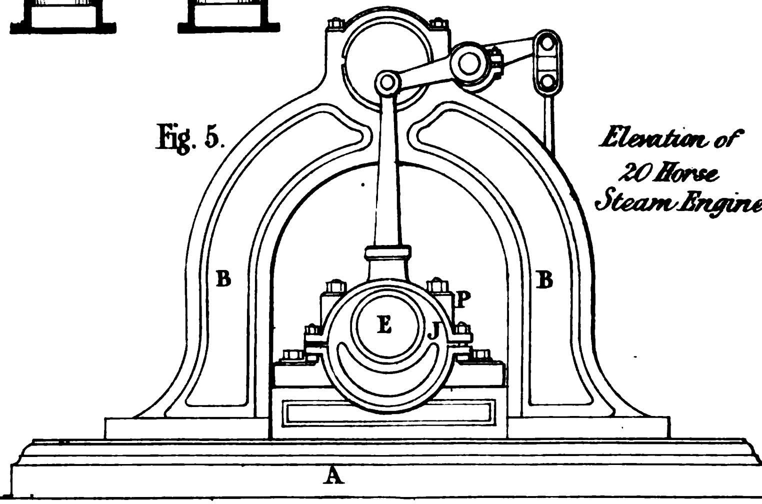
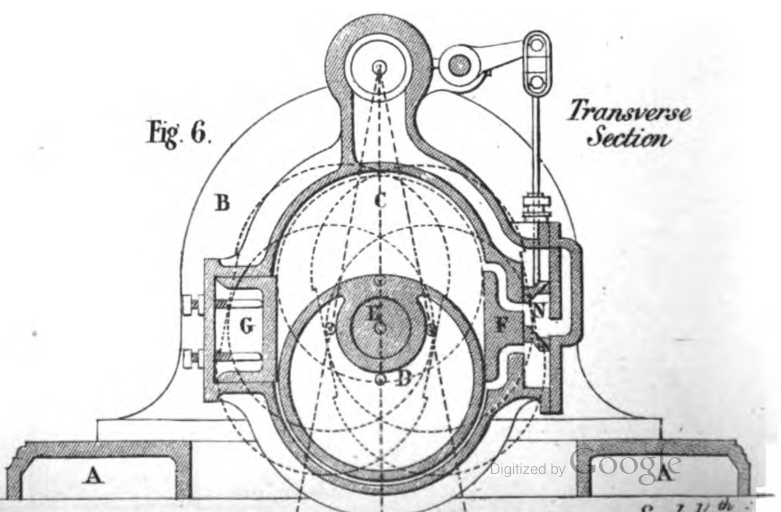


Fig. 5.



Elevation of 20 Horse Steam Engine

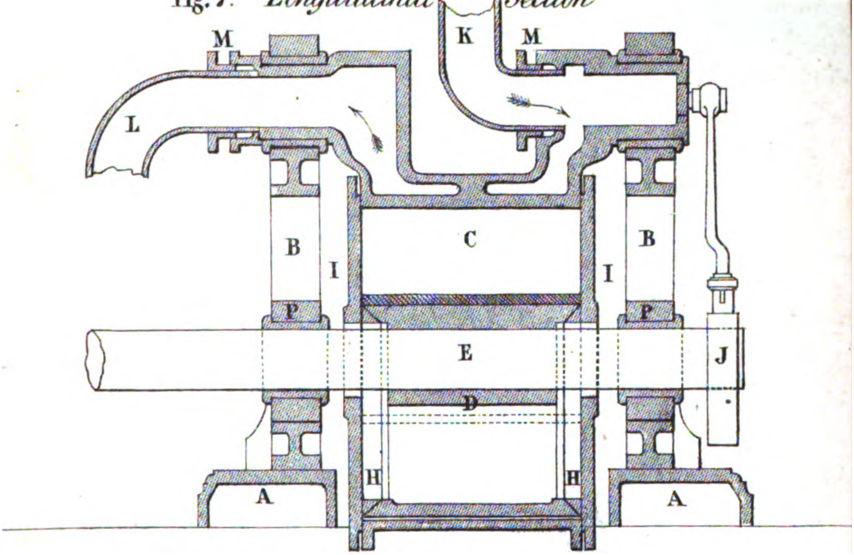
Fig. 6.



Transverse Section

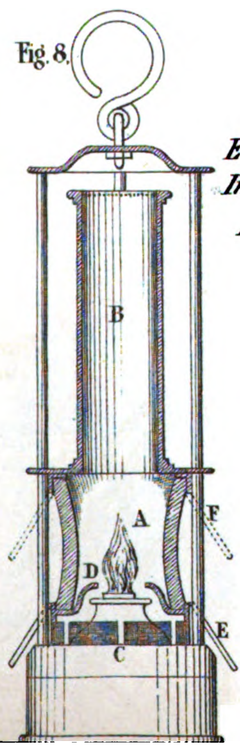
SHIPTON'S PENDULOUS ENGINE.

Fig. 7. *Longitudinal Section*



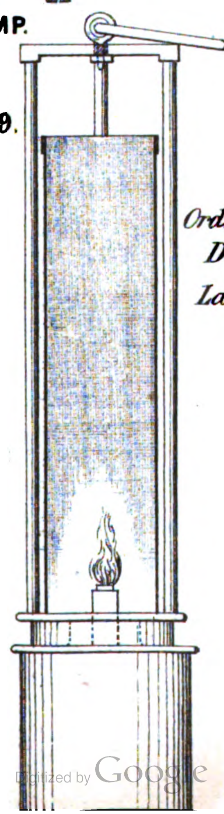
MINER'S SAFETY LAMP.

Fig. 8.



Elvin's Improved Lamp

Fig. 9.



Ordinary Davy Lamp

Scale 1/3rd size.

Plate 44

CREOSOTING TIMBER.

Fig 1 *Transverse Section of Pressure Tank*

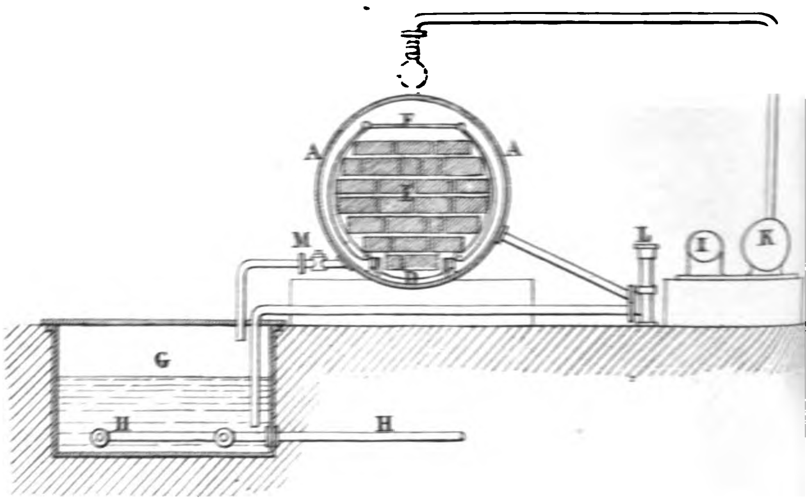
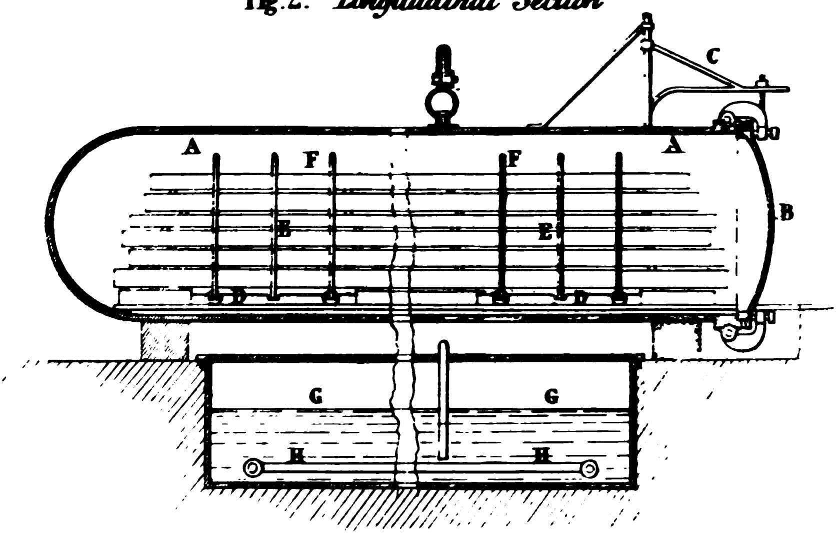


Fig. 2. *Longitudinal Section*



ale 1/70th size

CREOSOTING TIMBER.

Fig. 3. *Transverse Section of Drying House*

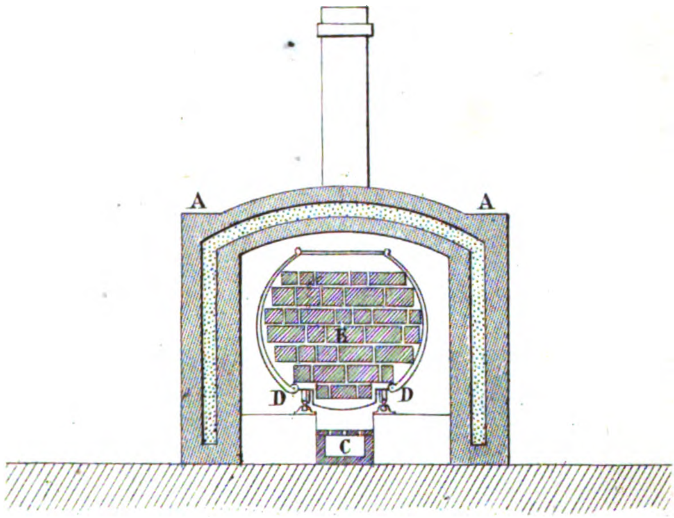
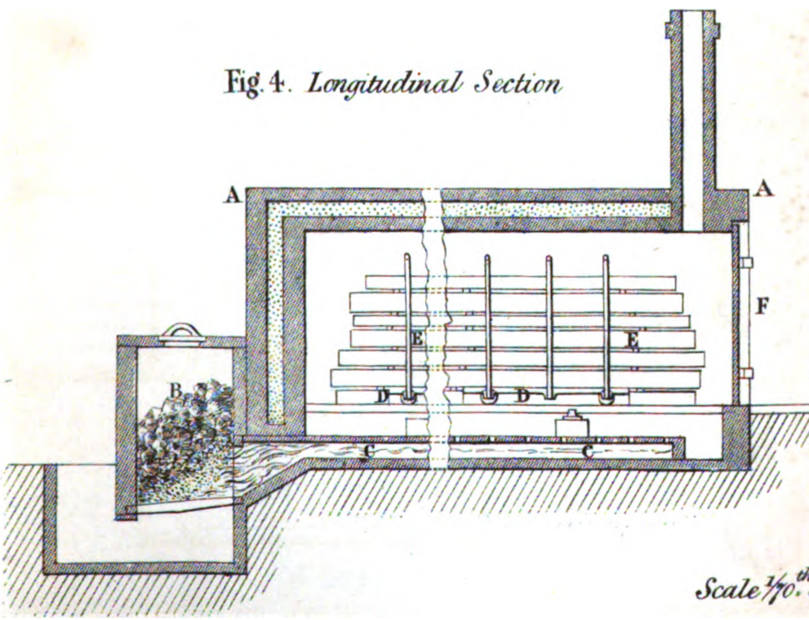


Fig. 4. *Longitudinal Section*

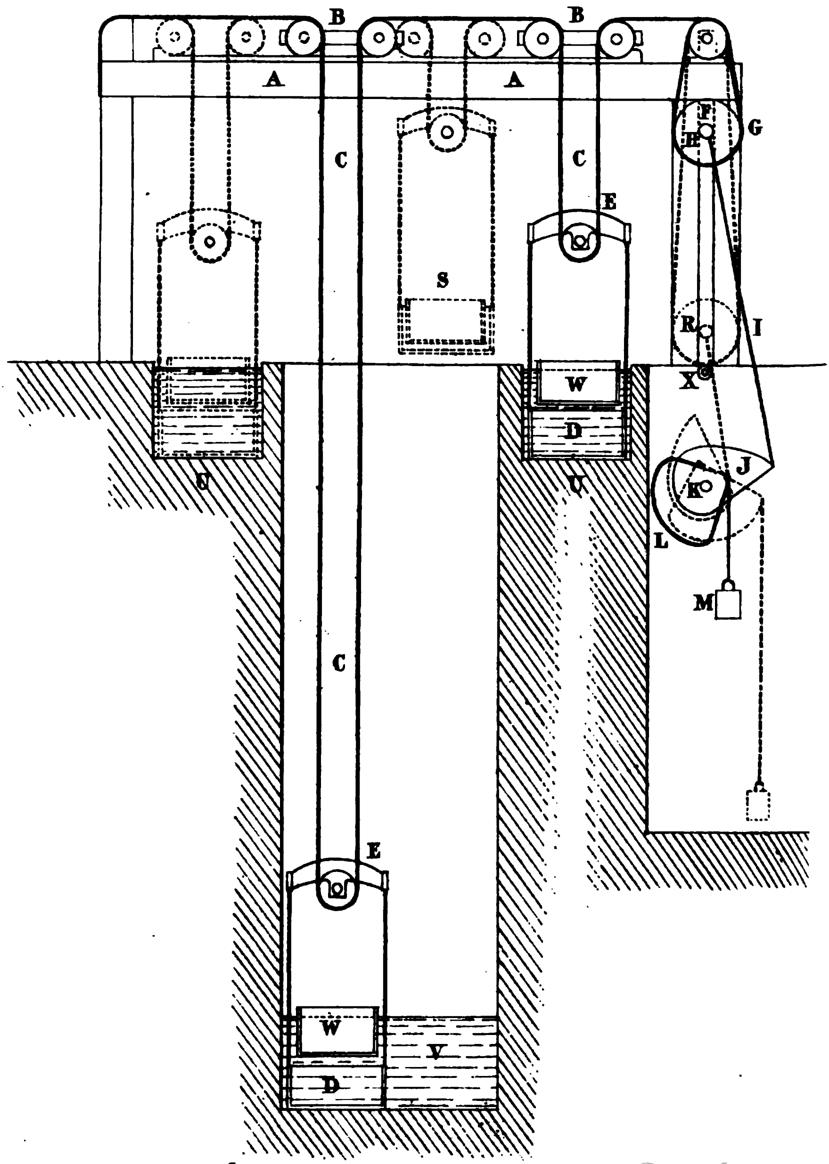


Scale 1/70th

Plate 46

CANAL LIFT.

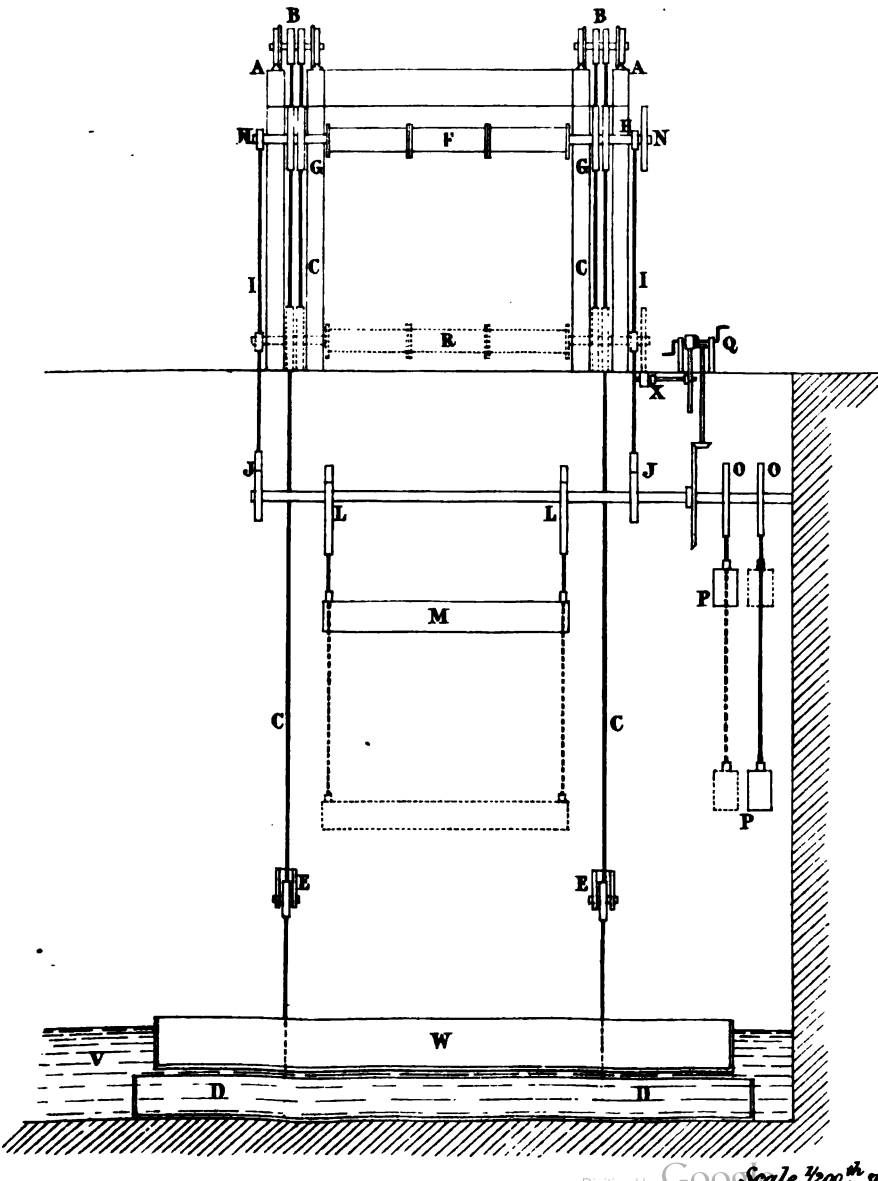
Transverse Section



Scale 1/200th size

CANAL LIFT.

Longitudinal Section.



Scale 1/200th size

INSTITUTION

OF

MECHANICAL ENGINEERS.

PROCEEDINGS.

1852.

PUBLISHED BY THE INSTITUTION.

54, Newhall Street, Birmingham.

1852.

BIRMINGHAM:

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INDEX.

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INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

FIFTH ANNUAL GENERAL MEETING,

HELD IN BIRMINGHAM, ON 28TH JANUARY, 1852.

J. E. Mc CONNELL, ESQ., VICE-PRESIDENT,
IN THE CHAIR.

BIRMINGHAM:
PRINTED AT M. BILLING'S STEAM PRESS OFFICES,
74, 75, & 76, NEWHALL STREET.
1852.

PROCEEDINGS.

The Fifth Annual General Meeting of the Members was held at the House of the Institution, Newhall Street, Birmingham, on Wednesday, 28th January, 1852, J. E. McConnell, Esq., Vice-President, in the Chair.

The Minutes of the last General Meeting were read by the Secretary, and confirmed.

The Chairman then read the following

REPORT OF THE COUNCIL,

AT THE FIFTH ANNUAL MEETING OF THE INSTITUTION OF MECHANICAL ENGINEERS.

The Council have the pleasure of meeting the Members on this Fifth Anniversary of the establishment of the Institution, and of congratulating them on its continued prosperity and increasing efficiency in promoting the objects for which it was founded.

The number of Members, &c., for the last year is 203, of whom 15 are Honorary Members, and 4 Graduates.

The Financial statement of the affairs of the Institution for the year ending 31st December, 1851, shows a Balance in the Treasurer's hands of £202 15s. 2d., after the payment of all accounts due to that date. The Finance Committee have examined and checked all the receipts and payments of the Institution for the last year, 1851, and have reported that the following Balance Sheet, rendered by the Treasurer, is correct.

(See Balance Sheet annexed.)

The Council have the pleasure of announcing that the following donations to the library of the Institution have been received during the past year :—

D. K. Clark, on Railway Machinery, from the Author.

W. Fairbairn, Lectures on the Construction of Boilers and on Boiler Explosions, from the Author.

H. Lund on the Law of Patents, from the Author.

J. Weale, Dictionary of Terms in Engineering, &c., from the Editor.

Minutes of Proceedings of the Institution of Civil Engineers.

The Mechanic's Magazine, from the Editor.

The Practical Mechanic's Journal, from the Editor.

The Civil Engineer and Architect's Journal, from the Editor.

The Artizan, from the Editor.

The Mining Journal, from the Editor.

The London Journal of Arts, from the Editor.

The Patent Journal, from the Editor.

Bust of Thomas Telford, by Mr. Peter Hollins.

Portraits of Messrs. George Stephenson, Robert Stephenson, Joseph Locke, and George P. Bidder, from Mr. Henry Wright.

The Council cannot but record their sense of the value and interest of the papers that have been presented to the Institution during the last year, and their thanks to the authors of the papers for the useful practical information they have furnished to the Institution. They have good prospect of continued advancement in the importance and number of the communications brought before the Institution, and have promises of several valuable papers for the ensuing year.

The following papers have been read at the Meetings in the last year :—

The Improvement of the Construction of Railway Carrying Stock, by W. A. Adams, Birmingham.

An Improved Water Meter, by W. Parkinson, London.

The Locomotive Workshops of the Manchester, Sheffield, and Lincolnshire Railway, by R. Peacock, Manchester.

An Improved Vacuum Gauge for Condensing Engines, by F. Bramwell, London.

An Improved Axle Box for Railway Engines and Carriages, by J. Barrans, London.

The Ventilation of Coal Mines, by Benjamin Gibbons, Dudley.

A New Machine for Blooming Iron, by Joseph Beasley, Smethwick.

The Improvements in Locks in the United States of America, by P. R. Hodge, London.

Improvements in the Construction of Railway Waggons, by H. H. Henson, London.

A New Regenerative Condenser for High Pressure and Low Pressure Steam Engines, by C. W. Siemens, Birmingham.

A New Blowing Engine Working at High Velocities, by Archibald Slate, Dudley.

An Improved Mode of Moulding Railway Chairs, by E. A. Cowper, Birmingham.

A New Pendulous Reciprocating Steam Engine, by J. A. Shipton, Manchester.

The Preservation of Timber by Creosote, by J. E. Clift, Birmingham.

A New Equilibrium Canal Lift, by A. Slate, Dudley.

An Improved Miner's Safety Lamp, by S. H. Blackwell, Dudley.

The Council are desirous to urge particularly on the Members the preparation of papers on some engineering subjects that have come under their attention, either as improvements in construction, or the results of experience and practical working; and they would especially call attention to the investigation of the following important subjects:—

The Explosions of Steam Boilers.
The Relative Economy of Stationary Engines for Manufacturing and Mining Purposes.
The Best Construction of Marine Engine Boilers.
The Comparison of Paddle-wheels and Screw Propellers.
The Construction of Iron Steam Vessels.
The Prevention of Explosions in Mines.
Improvements in the Construction of Railway Carrying Stock.
Improvements in Corn Mills.
Improvements in Self-acting Tools, and Workshop Economics.

A further list of proposed subjects for papers is appended; and the Council hope that all the Members will endeavour to prepare communications on some professional subjects that will be serviceable and interesting to the Institution, for the mutual advantage and information of the Members, as well as the general advancement of the interests of manufactures and commerce. They also invite the Members to aid as much as possible in increasing the utility of the Institution by the formation of a collection of mechanical models and drawings, and books for the library, with indicator-cards from steam engines, and statistical returns of the working of engines, &c., so as to render the Institution a complete place for reference on mechanical subjects.

The Council refer with satisfaction to the Meeting of the Institution that was held in London in the last year, during the Great Exhibition of Industry, at which a number of distinguished foreign engineers and scientific men were present, including Foreign Jurors of the Exhibition, and they were afterwards entertained at a dinner given by the Members of the Institution, in celebration of the occasion, at which 170 of the members and their friends were present, forming an interesting and agreeable assembly.

The Officers of the Institution, and Five of the Members of the Council in rotation, go out of office this day, according

.. the Rules, and the ballot will be taken at the present Annual Meeting for the election of the Officers and Council for the ensuing year.

The CHAIRMAN observed, that, on the present occasion of their fifth anniversary, they could look back with great satisfaction to the progress of the Institution, and the warmest expectations of its originators had certainly not been disappointed. Many valuable papers had been brought out by the Institution of mutual advantage to the members, and often productive of useful suggestions to the authors of the papers from the discussions that took place at the meetings. He trusted that what had been begun so well, would be carried on in the same spirit, for the Institution might be considered as still only in its infancy; and it was the duty of all the members to assist and support the Institution, by furnishing all the information in their power. Such a means of developing mechanical knowledge and manufacturing energy, as this Institution afforded, would prove a commercial advantage to the country generally, and they could only succeed in keeping their national position in machinery and manufactures, by uniting together in the encouragement of such Institutions. The prominent position of this country in the markets of the world, was maintained principally by the development of those mechanical resources which economise labour; and last year's Exhibition showed them pretty plainly, that to maintain that position they must energetically follow out the course of improvement which had first given England her supremacy. The Chairman hoped their numbers would be increased by younger members, in the class of graduates, who would be of good service to the Institution, to rise up in time and succeed to the places of the older Members. Every practical man had daily passing under his notice much of valuable information, which would be serviceable to the Institution, and he hoped that every Member would communicate such practical information, and avail himself of the

assistance of the Secretary for the purpose, who would afford every facility in preparing it; as it often occurred that those who had the most information to communicate had the least time to spare for it, or they were not aware that the information would be serviceable to the Institution.

Mr. THORNTON moved the adoption of the Report, and observed that he considered the progress and the present position of the Institution was very satisfactory.

Mr. HENSON seconded the motion, which was passed.

Mr. SHANKS moved a vote of thanks to the Council of the Institution, for their services during the past year, which was seconded by Mr. GARLAND, and passed.

The CHAIRMAN then announced that the ballot papers had been opened by the Committee appointed for the purpose, and the following Officers and Members of Council were elected for the ensuing year. He observed that the Committee had reported that a number of the ballot papers sent in by the Members had to be rejected as informal, because the Members had sent the papers blank, without indicating the names that they voted for.

President:

ROBERT STEPHENSON, M.P., London.

Vice-Presidents:

CHARLES BEYER, Manchester.
J. E. MCCONNELL, Wolverton.
JOHN PENN, London.

Council:

MATTHEW KIRTLEY, Derby.
JOHN R. MCCLEAN, London.
R. B. PRESTON, Liverpool.
JOHN RAMSBOTTOM, Manchester.
THOMAS WALKER, Wednesbury.

(In addition to the Ten Members of Council who continue in office from the last year.)

Treasurer :

CHARLES GEACH, M.P., Birmingham.

Secretary :

WILLIAM P. MARSHALL, Birmingham.

The CHAIRMAN announced that the following new Members were also elected :—

Members :

ALEXANDER BROGDEN, Walsall.
HENRY BROGDEN, Walsall.
THOMAS FAIRBAIRN, Manchester.
JAMES FENTON, Low Moor.
JAMES HOLCROFT, Shut End.
REUBEN PLANT, Brierley Hill.

The following paper, by Mr. Andrew Lamb, of Southampton, was then read :—

ON AN IMPROVED BOILER FOR MARINE ENGINES.

The Peninsular and Oriental steam ship "Ripon" is an iron vessel, of 1650 tons burthen, and has two oscillating engines, of 450 nominal horse-power. She was built by Messrs. Wigram, in 1846, and was supplied with her machinery by Miller, Ravenhill, and Co., of London, since which time she has been almost constantly running for the conveyance of the Indian Mail from Southampton to Alexandria.

Her average speed for the whole of this time has been 9·1 knots per hour. The boilers fitted to her by Messrs. Miller were of the ordinary tubular construction. They were in six pieces, had twelve furnaces, and 744 iron tubes, 3¼ inches outside diameter, 6 feet 6

inches long. The total fire-bar surface was 212 square feet, and the heating surface in tubes 3798 square feet, reckoning the whole of the inside surface of the tubes as effective.

The sectional area through tubes equals 36¼ square feet; ditto through ferules, 28 square feet. These boilers were loaded to 10 lbs. on the square inch, but in consequence of being deficient in steam, the actual pressure attained at sea very seldom exceeded 4 to 6 lbs. when full steam was admitted to the cylinders;—of course the engineers found it to their advantage to keep it up to its full pressure by working the expansion apparatus. This deficiency of steam was found to be an increasing evil, the cause for which may be satisfactorily explained by a little consideration of the *modus operandi* of the sea-going Tubular Boiler. When commencing running with the boilers new, for a short period, dependent on the species of coal consumed, the Tubular Boiler offers its greatest advantage, and is in fact (when properly constructed) as good an apparatus for evaporating water as can be imagined applicable to marine purposes. The tubes give an immense amount of heating surface, and in small compass, and from their form are capable of resisting great pressure, but after three or four days' steaming these advantages diminish. The tubes have an accumulation of soot and light ashes inside them, which by reducing their sectional area, sometimes from 50 to 75 per cent., diminishes the draught through the furnaces in the same proportion, and also reduces the effective heating surface to the same serious extent. This accumulation depends in quantity very much upon the coal. On one occasion the author was present in a vessel with Tubular Boilers, burning Scotch coal, and they actually came to a dead stand, after only sixty hours' steaming, the tubes being nearly choked up, and requiring to be swept. When Tubular Boilers have made a few voyages at sea, the outside of the tubes becomes encrusted with saline matter, which gradually accumulates upon them, chiefly upon their bottom sides, and which hitherto it has been found impossible to remove by any other means than scaling them mechanically. The situation of the tubes (row over row) prevents this being accomplished, excepting upon the upper tiers, and the consequences are that the tubes become coated with a crust ½ or ⅜ths of an inch thick, and the tube-plates also, which

from its non-conducting nature greatly retards the transmission of the heat through it, and the tube-plates becoming hot, crack and blister, and deteriorate very rapidly.

For the Boiler to be described in the present paper, invented and patented by the author in conjunction with Mr. Summers, the following advantages are claimed over its Tubular competitor:—

1st.—That, while it possesses an equal amount of heating surface in the same space as Tubular Boilers, it is free from the evil of choking with inside deposits of soot and ashes, because the flues being in one sheet for their whole depth, the deposit falls into the bottom of the flues, and is swept by the draught through into the uptake, and thence into the chimney.

This Improved Boiler, as adopted in the "Ripon," is shown in the accompanying drawings, Figs. 1, 2, and 3, Plates 48 and 49.

Fig. 1 is a transverse section, Fig. 2 a longitudinal section, and Fig. 3 a plan, all taken through the flues. AA are the Improved Flues, which are fixed in the same position as the tubes in an ordinary Tubular Boiler, forming the return passage from the back of the fire-grate at C to the uptake at D. EE are the smoke-box doors, and F the fire doors. The flues AA are flat rectangular chambers, 6 feet 9 inches long, and 3 feet 3 inches high, open at each end where they are fixed to the boiler. There are seven of these flues to each fire-grate; the smoke spaces are $1\frac{3}{4}$ inches wide, and the water spaces $2\frac{5}{8}$ inches. The sides of the flues are $\frac{1}{4}$ inch thick, and they are supported by the stays BB, fixed inside the flues. From this circumstance of there being no stays or other projections in the water spaces, an important advantage is gained—that no nucleus is offered round which the scale can collect, and no impediment to interfere with the complete and rapid cleansing of the water spaces from scale by means of the ordinary scrapers.

In another arrangement of these Boilers, adapted for large screw steamers, and also for war steamers, the flues are placed alongside the furnaces and at the same level, instead of over the furnaces as in the engravings, which arrangement protects the boilers from shot, by keeping them below the water line.

In these Improved Boilers the same amount of heating surface

can be obtained in the same capacity of boiler as with tubes; the only difference is, that if the tubes are $\frac{3}{16}$ths of an inch thick they will of course be rather lighter than $\frac{1}{4}$-inch plates; but this difference as compared with the gross weight is so small as to be unimportant. In the event of any accident to any of the flues, they may be taken out, separately or collectively, to be repaired or replaced with new ones; but from the facility with which they can be kept clean, they ought, as in the old-fashioned flue boilers, to wear out the shell; the length of time being remarkable that a *thin* plate will last, if kept clean, and never overheated.

The last boilers of this construction examined by the author were those of the "Tagus," 280 horse-power, and in those boilers, after six days steaming, the deposit was only three inches deep in the bottom of each flue; and the total depth of the flues being 3 feet 8 inches, it follows that she had only thus lost about 6 per cent. of sectional area.

2nd.—That the Improved Flues, from having no projection either of rivet heads or stays in the water spaces, offer no obstructions whatever to the scaling tool, and are as easily kept clean as any part of any boiler can possibly be, thereby entirely removing the evil of a loss of heat through non-conducting deposits, and very much increasing the durability of the Boiler.

3rd.—That the water spaces between the flues being comparatively large, and the sides of the flues perfectly vertical, the circulation of water in the boiler must necessarily be much more perfect than amongst a number of tubes (amounting sometimes to thousands), where the water has to wend its way in and out in curved lines. This greater perfection of circulation, the author thinks, must add greatly to the effectiveness of the heating surface in the Improved Flues.

It must be here mentioned that these advantages do not now rest upon theory only, and that they have been fully realized by experience.

The first boilers fitted with these flues were those in the "Pacha," in October, 1849, similar to those shown in the engravings, and up to the time of her unfortunate loss these boilers gave entire satisfaction. Then followed a small boat, in January, 1850, and the

"Tagus," in August, 1850, since which their success has been rapid, as a proof of which, numerous vessels of different companies are being and have been fitted with them. The "Tagus" has now the oldest of the boilers, and there is in no part of them any signs of deterioration whatever; in fact they are in every way perfect. There has never been any leakage, and the consumption of fuel is less than with her former Tubular Boilers.

The Improved Boilers now fitted to the "Ripon," were manufactured by Messrs. Summers, Day, and Baldock, of Southampton, and are in four parts; the boilers being placed in the wings, two forward of the Engines, and two aft, the stokeholes are thus in midships.

The space occupied by these new boilers is the same as the old ones, the arrangement mentioned having economised as much room as the increased size of boilers required, so that the same quantity of coal is carried in the same space as before. The new boilers have 16 furnaces and 246 square feet of fire-bar surface: 112 flues, 3 feet 9 inches deep $\times$ 6 feet 3 inches long, being 5440 square feet of heating surface, reckoning the whole inside surface (as in tubes); the sectional area through the flues, deducting the stays = 54 square feet.

This large sectional area can be diminished at pleasure by a grating damper, which is hung at the front end of the flues, and extends about 10 or 12 inches down them, and which is worked by handles placed outside the boiler and between the hinges of the smoke-box doors. The Engineer can thus regulate the intensity of his draught at pleasure, according to the variety of coal in use, &c., &c.

The new boilers of the "Ripon" are loaded to 13 lbs. per square inch; the flues, being strongly stayed inside, would of course resist a far higher pressure with perfect safety; in fact, if required, they might easily be sufficiently stayed to resist steam of any pressure.

The "Ripon," at the same time that the boilers were altered, had her common radial paddle-wheels replaced by feathering ones, which consequently added much to the speed of the vessel.

The best speed of the engines of the "Ripon" with the old arrangement was about 15 revolutions per minute, and that of the vessel about 10 knots per hour when quite light.

On the trial at the measured mile, December, 1851, the vessel was drawing 16 feet 3 inches forward, and 16 feet 7 inches aft; she had all her coal, (422 tons,) on board, her water, and some cargo, and consequently was pretty deep loaded. The speed of the engines was 19¼ revolutions per minute, and of the vessel 11·3 knots per hour. Had she been light, as in the former trial, she would have probably gone over 12 knots. It appears, therefore, that the improvement in speed may be fairly stated as 2 knots per hour. The cylinders of the engines are 76 inches diameter × 7 feet stroke. Their nominal horse-power formerly, at 15 revolutions, would be 404, and at 19¼ revolutions, 526 horse-power, so that the new boilers have given 122 horse-power more steam, of an increased pressure of 3 lb. per square inch, than the old ones. As the "Ripon" is now making her first voyage with the new boilers, the author cannot speak with any certainty about her consumption, but will give some details of the Peninsular and Oriental steam ship "Bentinck," which has made one voyage to Alexandria and back with these improved boilers and feathering wheels.

The "Bentinck" is a wooden vessel, built by Wilson, of Liverpool, in 1844; and has side lever Engines, by Fawcett and Preston. She is 2020 tons burthen, and her Engines are 520 nominal horse-power; her original boilers were of the old flue construction, and were loaded to 6 lbs. per inch pressure; her average speed at sea was 9 knots per hour, and her Engines about 14 revolutions per minute.

The speed of the "Bentinck" is now over 11 knots per hour. The former consumption was about 37 cwt. per hour; the present consumption averages about 38 cwt. per hour.

It must be noticed that the Peninsular and Oriental Company had Tubular Boilers, with brass tubes, made for this vessel by Messrs. Bury, Curtis, and Kennedy, and that they were brought to Southampton, and placed in the "Pottinger," a sister ship of the "Ripon," and of 450 nominal horse-power, with common paddle-wheels: these boilers are of exactly the same size as the patent boilers made for the "Bentinck," and they are both loaded to the same pressure, viz., 12 lbs. per square inch; they have each made a passage to Alexandria and back, and, contrary to all expectation,

the "Bentinck," although her Engines are 70 horse-power nominal more than the "Pottinger," and are working up to 103 horse-power more, has consumed 128 tons less coal than the "Pottinger," and performed the same distance in 68½ hours less time. This result of diminished consumption is undeniably a fair triumph for the Improved Boiler; as for the improved speed of the vessel, it must share the honours with the feathering paddle-wheel; the "Bentinck" has made the fastest passage on record between the ports mentioned.

In conclusion, the author can only say that he believes the Improved Boiler described in the present paper will become the Marine Boiler generally adopted; as its merits are evident, and its cost is not greater than Tubular Boilers; while its durability will, he thinks, be very much greater. He will be happy to show these Boilers to any of the Members of the Institution who may have an opportunity of seeing those that may be in port, or at Mr. Summers' Works at Southampton, where there are now five sets in course of construction. It may be added that the screw steam ship, "Glasgow," by Messrs. Todd and Mc Gregor, which has lately made the fastest run across the Atlantic of any screw steamer, is fitted with these Improved Boilers; Messrs. Todd and Mc Gregor have made a considerable number of them, and they are also being manufactured by several others. It is intended also to adopt these boilers in the "Himalayah," now building for the Peninsular and Oriental Co., of upwards of 3000 tons burthen, to be propelled by oscillating engines of 1200 horse-power.

[*Note.*—The details of construction of the flues are shown in Figs. 4, 5, and 6, Plate 40; Fig. 4 is a transverse section, Fig. 5 a plan, and Fig. 6 a longitudinal section of a portion of the flues AA, shown on an enlarged scale. They are constructed of two flat side plates GG, ½ inch thick, flanged outwards at each end to meet the plates of the adjoining flues; the top and bottom of each flue is formed by the curved connecting piece HH, which is rivetted to each side plate, and flanged outwards at the ends. The stays or studs BB, are 1½ inch diameter, and are rivetted at each end through the side plates. The rivets connecting the plates together, and the stays, are all put into their holes simultaneously, and rivetted cold by machinery. These rivets have countersunk heads and points, and when placed in their holes in the plates a steel bar is inserted, which fills up the space between the heads of the two rows of rivets, and acts as a bolster to the rivetting tool. By this means one stroke of the machine closes two rivets at once, and in the most efficient manner. The flues are afterwards rivetted

together with covering strips I I at their ends, and they are inserted into the boiler in sets of seven or eight, according to the size of the furnace.

Any one of the flues can be readily extracted from the others if necessary, by cutting away the two rows of rivets at each end, and drawing it out through the front smoke-box doors E. The experience which they have had of the durability of the flues has, however, satisfied those who have employed them, that unless gross negligence of the engineer should (through want of water) allow them to get red hot, the flues will in all cases outlive the shells in which they are inserted.]

The CHAIRMAN observed, that he regretted Mr. Lamb was not able to be present on that occasion, to have given them further practical information on the construction of the boiler that was desirable. He had not explained in the paper the mode of fixing the flue-plates to the boiler at each end, and the mode of removing and replacing the flues when required.

Mr. SHANKS said he had seen some of the boilers on that plan making at Glasgow, but was not acquainted with the practical details.

Mr. E. JONES thought there would be some practical difficulty in removing and replacing the flue-plates without disturbing the boiler.

The CHAIRMAN remarked, that the question of principle in the boiler was one of heating surface, and there was certainly a considerable advantage in having only the small horizontal surface at the bottom of the flues for the deposit to collect upon, and the vertical position of the plates allowed the freest fall for the deposit to the bottom.

Mr. COWPER said the construction of the boiler reminded him of Hancock's boiler, which was invented for common road locomotives; that boiler consisted of a number of very thin flat chambers, with a number of stays passing through all the chambers, which were in tension instead of compression as in Mr. Lamb's boiler: these stays passed through a series of ferules, or very short tubes, forming struts both inside the chambers and

between them. The boiler was very complicated, from having so great a number of joints, and was consequently very troublesome to keep steam-tight; but it was a very effective plan for generating steam, and very economical of space; the air came away from the flues as cool as in a locomotive chimney. A short narrow flue is equal to a long wide flue, as in the large flue boilers, for extracting the heat out of the air passing through it, as the whole of the air is brought so much sooner in contact with the sides of the flue.

Mr. MIDDLETON said that the boiler described in the paper reminded him of another boiler somewhat similar to Hancock's, where there was great difficulty in keeping it steam-tight. The bottom of the flues was not considered so good a heating surface as the top of the flues, and therefore in Mr. Lamb's boiler the whole of the sides of the flues should not be calculated as efficient heating surface: he thought two thirds would be enough to take.

Mr. COWPER observed, that would be merely a question of what value was put upon the heating surface per square foot. But there would be more loss from that cause in tubes than in Lamb's flues, as the bottom surface of each tube amounted to a fourth or more of the whole heating surface; but in Lamb's boiler the bottom surface of the whole flue was only equal to the bottom of one tube.

The CHAIRMAN considered it desirable to obtain further particulars from Mr. Lamb respecting the boiler, and its relative evaporating efficiency as compared with the ordinary tubular boiler.

Mr. SHANKS said, that Messrs. Todd and McGregor had last year built for the Peninsular and Oriental Co., two vessels exactly the same in every respect, except that one had tubular boilers and the other Lamb's flue boilers: they were both, he believed, performing their voyages in the Indian ocean, and they would supply an excellent means of making a comparison between the two constructions of boilers, and he hoped Mr. Lamb would report the results of this trial to the Institution.

Mr. ALLAN suggested, that the flues might be put in with a

flange all round at each end, like the mid-feather in a locomotive firebox, and fixed by two rows of rivets down each water space. The rivet heads might then be readily cut off all round any one flue, and the flue taken out, when required; and a new flue might then be inserted, by reaching down the water spaces between the flues to put the rivets in.

Mr. Cowper observed, that he had once been told by Mr. Preston, of Liverpool, of a tubular boiler of ordinary construction in a steamer on the Mersey, which did not make steam enough; and he found on examination that the tubes were all set solid together with the deposit formed between them, so much so, that he cut off all the tubes at each end inside the tube-plates, and took them all out in one mass.

Mr. Shanks said, he remembered the boilers of the "Caledonia" steamer, after seven years' work across the Atlantic, were found to be still in good condition, and with very little scale upon them; they were common flue boilers, and were kept clean chiefly by the constant use of the brine pump. He enquired whether, in stationary boilers, Ritterbandt's plan of using muriate of ammonia did not prevent incrustation?

The Chairman observed, that Ritterbandt's process only removed the carbonate of lime, but did not act on the sulphate, which formed a large portion of the deposit.

Mr. Cowper said, he remembered trying that plan in a pair of stationary engine boilers, but after finding that it caused the engines to get quite rusted, the plan was abandoned.

The Chairman proposed, that the discussion on the boiler should be adjourned, and Mr. Lamb be requested to give them the further information respecting it at the next meeting; he proposed a vote of thanks to Mr. Lamb for his communication, which was passed.

The following paper, by Mr. William Handley, of London, was then read:—

ON AN IMPROVED BREAK FOR RAILWAY CARRIAGES.

A great variety of Breaks have been invented for stopping Railway Carriages, but nearly all of them act upon the same general principle, and are simply different methods of pressing blocks of wood against the circumference of the wheel, so as to stop its revolution, and cause the tire to slide upon the rails.

If the wheels are all stopped, the friction of the weight of the carriage sliding upon the rails is the whole amount of breaking power that can be obtained by any of the plans, and the different methods used to accomplish this add no power for stopping the carriages, but are only different ways of pressing the break-blocks against the tires, for the purpose of ensuring greater rapidity, certainty, and uniformity of action, reducing the expenses of repairs, and the jarring on the carriage—or to make the breaks self-acting, or worked in combination.

The principal object to be obtained is to have the blocks always pressed square against the wheels, and with a uniform pressure on all the wheels of the same carriage or waggon, &c.; unless this is effected there is great difficulty in stopping the wheels, and much straining is caused upon the carriage. In the earlier breaks the block is suspended by a vertical lever from the frame of the carriage or waggon, &c., as shown at C in Fig. 1, Plate 50, the block A being shaped to the circle of the wheel, but the varying height of the frame of the carriage, from the variation in the weight of load acting on the springs, causes much inequality in the fitting of the break-block to the wheel, from the relative level of the break-block and the wheel being changed, as shown by the dotted line, B B; also, the action of the springs is stopped by the pressure of the break, causing violent jarring and concussions, injurious both to the carriage and the road, and being very annoying to passengers.

The slide break, shown in Fig. 2, was invented for the purpose of remedying these defects. The relative level of the wheel and the break-block is preserved unchanged, by the break-block, A, sliding horizontally upon a bar, B B, which is carried by the axle-boxes at each end, C; a difficulty is experienced, however, in preserving an equal

pressure on all the break-blocks, on account of the unequal wearing of the different bearings.

All the above breaks have, however, the serious objection that flat places are worn upon the tires of the wheels, by sliding upon the rails, and the wheels consequently become, to a certain degree, polygonal. Any deviation from the circular form of the wheel becomes a serious source of injury both to the rails and the wheel, from the amount of concussions caused by the great velocity of rolling, and the great weight carried; this also causes increased expence in the wear of the tires and rails.

Fig. 3, Plate 50, shows another break, invented by Mr. Lee, in 1842; the wooden break-block, A, is made of a triangular form, and is pressed both against the wheel and the rail by the lever, B, which is centred upon the nave of the wheel, C, by means of a ring or collar fitting in a circular groove cut round the nave; the rubbing face of the wood block is shod with copper or iron. The connecting rods, D D, have adjusting screws, to preserve the relative position of the break-block, A, and the wheel, as the surface of the block wears away.

The mechanical arrangement of this break, it will be perceived, does not admit of sufficient pressure being applied against the wheel and the rail to form an efficient break; but even if the pressure were sufficient to stop the wheel, the same objection would still apply as in the ordinary break, namely, flat places would be worn on the wheel. This break was tried on one or two railways, but has not come into use.

Fig. 4 shows a break on an entirely different principle, brought out by Mr. Adams, in 1847; this consists of a sledge, A A, sliding upon the rails, upon which the whole weight of the carriage is thrown by lifting the wheels off the rails. The sledge A A is a long piece of iron, with a flange at each end to guide it on the rails, and is suspended by two links, B B, from the iron bar C C, which is supported by the links D D, and bears against the under side of the axle-box at each end, E E; the links B B are in the form of a parallel rule, and when they are straightened by the action of the lever, the sledge A A is pressed upon the rails, and lifts up the wheels from their bearing on them. This break saves the wheels from being worn flat; but it requires great power to put the whole weight of the carriage upon the sledge, and is

consequently slow in action; and there is also an objection to it in having the wheels hanging without any support when the break is in action. It has not come into use in England, but there were several breaks on the same principle in use in Belgium for some time previously.

Handley's Improved Break, the subject of the present paper, is shown in Figs. 5 and 6, Plate 51. This break is on the same principle as the ordinary skid used on common roads; the two iron arms, A A, are carried by the axle, B, upon which a brass ring, H, is fitted, turning round the axle; and at the ends of these arms are fixed the shoes or skids, C C, one of which is made to pass under the wheel, whichever way the carriage is running, raising it from the rails by turning the lever round upon the axle. The shoe is made the breadth of the tread of the wheel, without any flange, and the wheel is lifted only about one eighth of an inch on the average, so that the flange of the wheel continues as efficient and secure a guide upon the rails as in the ordinary case of a wheel stopped from revolving by the pressure of a break-block. The shoe is made in two pieces: the upper one, C, is forged on to the arm A, and the lower piece, D, which forms the skid, is hinged to it at the end. The object of this construction is to prevent the shoe from touching the wheel until it is required to be put in action; the joint opens about a quarter of an inch, and the shoe falls away from the wheel when it is lifted, being stopped by the bolt E, which limits the extent of its opening; and round this bolt is placed a short spiral spring, to keep the joint open, and prevent it from shaking when the carriage is running.

The wear of the shoe is provided for by inserting two small dove-tailed pieces, F and G, at the points where the wear takes place; these pieces are slightly tapered, and are driven into their places from the inner side, being burred or rivetted on the opposite side, where they remain firmly fixed, having no tendency to work loose. The lower piece is of wrought iron, which is found to answer best for the purpose; the upper one, F, which carries the wheel, is of cast iron: it has very little wear upon it, but is changed occasionally for a piece of greater thickness, to allow for the wear of the shoe-plate G, and preserve the total thickness of the shoe, within very little variation, so as to prevent much difference in the height that the wheel is lifted from the rails.

This break is easily and quickly applied, by means of the lever, L, acting on the upper arm of the break, K, as the carriage runs upon the shoe when it is pressed under the wheel; it requires less force than the ordinary break, and is put on more quickly. The ordinary break screw, lever, and cross shaft, are available for working this break.

This mode of breaking has the advantage of keeping the wheels perfectly circular, and preventing them wearing polygonal, which under the ordinary mode converts them, in fact, into so many hammers beating upon the rails, to the no small detriment of the permanent way.

As the wheels rest upon the skid, which slides along the rail, the axles are saved from that strain and torsion which necessarily arise when blocks are pressed with great force against the wheels to stop them. Instances often occur of the axles of break carriages failing from this cause.

When wheels are stopped with the ordinary break, the surface bearing upon the rails is so small that it follows into the soft and hollow places of the rails, and makes them worse; this shoe, however, having a bearing of sixteen inches, passes over them, and saves the rails from that wear.

In consequence of the axle being taken for a bearing, and the pressure being downwards, in the same manner as when the wheel *is* running, the action of the springs is not in the least interfered with, and the carriage runs as easily, and without any jar, when the break is put on as when it is off. The wheels are also kept quite cool, saving the tires thereby from expansion.

The retarding power of this break is found to be greater than that of any of the ordinary breaks, both in dry weather or when the rails are slippery; and it is found from experience that two pairs of wheels with this break are about equal to three pairs with the ordinary break.

In all the breaks where the wheel itself forms the shoe or skid, the weight of the carriage is carried on the small point of contact of the wheel, which immediately wears bright and clean, and the friction is thereby materially diminished; but in this break the much greater extent of surface in contact prevents it from getting rubbed clean and bright, and the particles of grit are retained between the rubbing surfaces, causing increased friction.

Several of these breaks are in use on the Eastern Counties Railway.

on break vans, and also applied to one pair of wheels of some tank engines running on branch lines; and they have worked constantly with entire satisfaction, from half a year to a year, working daily over the points and crossings of the stations, without any difficulty or accident having been experienced.

A break van, fitted with these breaks, has been running in a goods train for two years, averaging 700 miles weekly, and the shoe-plates put in six months since, still remain good. The shoe-plates of the tender breaks last about three months before requiring renewal, and those of the tank engines about two months.

The CHAIRMAN observed, that they were disappointed of Mr. Handley's presence, who was to have attended at the meeting; and in his absence the Secretary, Mr. Marshall, who had mainly prepared the paper and drawings, would afford any further explanation on the subject that might be required.

Mr. ADAMS said, he considered a sledge break was undoubtedly better than the ordinary plan of sliding on the wheel, if the practical objections and difficulties could be overcome, but he had never seen Mr. Handley's break before, nor a drawing of it. It would depend on the results of working, whether safely and satisfactorily; but he thought it would require much force to put on the break and lift the carriage.

The SECRETARY explained that the wheel mounted up the inclined point of the sledge by running in that direction, and that it was found not to require more force at the handle to put it on or take it off than the ordinary break; it was worked by a screw and lever in the ordinary manner, and 2½ turns of the handle were sufficient to put it on. In taking off the break it required a pinch at first to loosen the shoe, and then the weight of the carriage assisted in getting the wheel off.

Mr. HENSON thought the break was an ingenious principle, but did not quite approve the application; and he thought the ordinary breaks would afford more retarding power when they were made not quite to stop the wheels. A good breaksman knew

that by keeping the break-block pressed against the wheel with a little less force than would stop the wheel from revolving, he could produce a greater friction than by skidding the wheels.

Mr. CLIFT doubted the durability of the bottom shoe-plates, and thought they would be continually wanting to be renewed, which would involve great practical inconvenience and expense.

Mr. ADAMS observed that there was a great trouble and expense with the present breaks, in constantly changing the wood break-blocks, which wore out in a very short time where there was much work to be done. If the whole weight of the carriage were sledged, that must be the limit of breaking power, but it was clearly a bad mechanical arrangement to sledge it on the mere points of contact of the wheels on the rails.

The SECRETARY explained the provision made for changing the shoe-plates; these plates were all alike, planed to one gauge, with the same taper, so that each one would fit any break, and a stock of them was kept always ready, and any plate could be changed in a few minutes. The cost of these pieces of iron was very little, and they appeared to have great durability, those under the break-vans lasting more than six months.

Mr. PEACOCK was not acquainted with the break before, but he certainly thought it was an exceedingly good scheme, and well carried out. He enquired about the construction of the brass collar that carried the break upon the axle—whether it was fixed tight on the axle, or the axle revolved in it? he doubted whether it would last long, from the friction upon it.

The SECRETARY explained that the brass collar was fixed in the break, and turned loose on the axle; it was consequently always rubbing whilst the carriage was running, but the friction was very small, as the only pressure upon it was the weight of the break itself, which was suspended by the brass collar. When the break was in action there was no friction, as the axle was then stationary. A specimen was exhibited of one of these brass collars, $1\frac{3}{4}$ inch wide and $\frac{3}{16}$ inch thick, which had been six months at work in a break, but showed very little signs of wear.

Mr. Goodfellow did not understand how the wheel was prevented from mounting farther on to the shoe than was intended, and rolling over it; he thought it would be only prevented by the small bolt connecting the upper and lower pieces of the shoe, and that a stop was wanted for the arm of the break, to prevent it from moving too far.

The Secretary said that he believed a stop was provided for the break in the Tank Engines by making one of the arms of the break work inside a segment, which limited its motion both ways; but that there was no other stop in the break vans than the screw of the break handle, which was sufficiently powerful to pull back the break whilst the carriage was travelling forwards, and would, therefore, have power enough to hold the break from going farther under the wheel. The bolt connecting the pieces of the shoe was free, and had no strain upon it when the break was in action, as the two pieces were then pressed close together; but supposing the handle detached, the wheel could not pass over the shoe without tipping up on the front end of the shoe, as a centre, which was a long leverage.

Mr. Cowper remarked that if the proportion between the height of the axle from the rail, and the length of the base upon the rail from the centre of the wheel to the front end of the shoe, was only the same as the proportion between the total weight on ths wheel, and the sliding friction on the rail, then the wheel would be just on the point of rolling over the shoe; but if the proportionate length of the base upon the rail exceeded the limit of the sliding friction, the shoe must slide forward, and the wheel could not roll over it even if the break arm were loose from the handle, and free to revolve round the axle. In the drawing of the break, the angle at the front of the shoe appeared to be about 45°, so that the base on the rail was equal to the height, and the friction oould never be sufficient to prevent the shoe from sliding forward; nothing but a fixed obstacle could do so.

Mr. Adams considered the break must prove very economical, if it was found efficient in practice, from saving the extra

expence of repairs of the wheel tires, which was very great on lines with steep gradients, where the breaks were required to be in very frequent use. He wished to ask Mr. Peacock what he found the expence of keeping in repair the wheel tires of the break vans.

Mr. PEACOCK said that in the long steep inclines of the Manchester, Sheffield, and Lincolnshire Railway, they had the wheels of the break vans and tenders skidded for three or four miles together sometimes, and the wheel tires were worn out very rapidly in consequence; the men could not be prevented from skidding the wheels, where they had the power of doing so, by the break. The wheels required taking out and turning up about once in two months, and this process generally answered only twice, after which new tires were required; the cost of renewing the tires was about £10, and £2 more might be added for the intermediate turnings up and the cost of changing.

Mr. ADAMS observed that the annual expence caused by the wear of the wheel tires alone in the break waggons appeared, therefore, to exceed £15 per waggon, under the present system, and the consequent saving would be very important in that item alone, in a large stock of waggons, by the use of the new break preventing the polygonal wear of the wheels.

Mr. COWPER said he thought there was some objection to pushing a sledge in front of the wheels, in case of its catching against any fixed obstruction, such as a bad joint in the rails; although it was rounded off at the front end, it would wear into a flat surface, making an angle; but when a wheel was skidded it always presented a rounded surface to any obstacle; and if the obstacle did catch it, it only turned the wheel round a little.

The SECRETARY observed, that the shoe was made with a long gradual slope at the end, and however worn at the bottom, it would always leave so easy an angle in front as to pass over any joint as well as a skidded wheel could.

Mr. GOODFELLOW thought that a side wear of the flange of the wheel might be found to take place, particularly in passing round curves, which would wear out the tire, although the head

of the tire was not subjected to wear; and he doubted whether there was sufficient guide on the rail.

Mr. PEACOCK observed that the break-shoe might be made with a flange, which would obviate any wear on the flange of the wheel.

The CHAIRMAN remarked that it was an interesting and important subject, and this break was certainly a very ingenious invention, well deserving of a complete trial.

He proposed a vote of thanks, which was passed, to Mr. Handley, for furnishing them with the information, and to the Secretary for preparing the communication, which was passed.

The following paper by Mr. James Samuel, of London, was then read:—

ON A CONTINUOUS EXPANSION STEAM ENGINE.

THE economy of working steam expansively is well known, but the application of the expansion principle is practicable only to a limited extent in most forms of engine, from practical difficulties in their mode of working which prevent the attainment of the full economy of which the expansive principle is capable.

The greatest useful effect is obtained from the steam, when it is allowed to expand in the cylinder until its pressure upon the piston just balances all the useless resistances of the friction of the engine itself, and the resisting pressure on the back of the piston; (whether the pressure of the atmosphere, in a high-pressure engine, or of the uncondensed vapour, in a condensing engine,) the surplus power beyond these useless resistances being alone available for the purposes to which the engine is applied.

But in driving machinery, so great a uniformity of motion is essential, that any great variation in the moving power throughout the stroke of the engine is inadmissible, as the flywheel would not be able to absorb enough of the excess of power to equalise the velocity sufficiently, by giving it out again at the deficient part of the stroke; consequently, though two engines are often employed working at right angles to each other, for the purpose of diminishing the variation in

total moving power, the expansion principle can only be carried to a portion of the extent to which it is theoretically applicable.

Only in such engines as the large Cornish pumping engines can the expansion be carried practically to its full theoretical limit, as the variation in the velocity of the load moved is of much less importance in those engines, and the very unequal amounts of moving power that are developed in equal times, by the full carrying out of the expansive principle, which would produce the most prejudicial and inadmissible variations of velocity in the engine, are controlled within prescribed limits by the great weight of material to be moved by the engine in the pump rods and balancing machinery, forming as it were a distributing reservoir for the moving force developed.

In the Locomotive Engine there are practical difficulties in carrying out the expansion principle efficiently, beyond a moderate extent, in a single cylinder, from the shortness of stroke and rapidity of reciprocation, and the construction of the valve motion; but the ultimate extent to which it could be carried would be limited by the maintenance of the blast, which requires that the jets of steam discharged from the cylinder into the blast-pipe should not be reduced below a certain pressure at the moment of discharge. Otherwise, the limit to which expansion might be carried would be the resistance of the atmosphere to the discharge of the steam, added to the friction of the engine, say about 10 lbs. per inch above the atmosphere.

The steam is cut off usually by the link motion at from ⅓rd to ⅔rds of the stroke, and the steam is consequently discharged into the blast-pipe at about from 30 to 60 lbs. pressure above the atmosphere, supposing it to be supplied to the cylinders at 100 lbs. per inch above the atmosphere.

It appears that the lower of these pressures is sufficient, or more than sufficient, for the purposes of the blast, to maintain fully the evaporative power of the boiler under general circumstances, and that a portion of the steam discharged can be spared from the blast to be subjected to a greater extent of expansion.

In the Continuous Expansion Engine, the subject of the present Paper, the steam from the boiler is supplied only to one cylinder; a portion of it is expanded into the second cylinder, which is of pro-

portionately larger area, so as to equalise the total moving power of the two cylinders; and it is there further expanded down to the fullest useful extent, and then discharged into the atmosphere, the portion of steam remaining in the first cylinder being discharged as a blast at nearly the same pressure as the ordinary engines. The economy, therefore, consists in obtaining from such portion of the steam as can be spared from the blast the additional power of expansion remaining in it, which is thrown away in the ordinary engine.

Figs. 1 and 2, Plate 52, show the Continuous Expansion Engine as applied to a Locomotive. A is the first cylinder into which the steam is admitted from the steam-pipe, C, by the valve, D, in the same manner as in the ordinary engines. The steam is cut off at half stroke, and a communication is then opened with the second cylinder, B, through the passages H and F, by the opening of the slide valve G. The second cylinder, B, is about double the area of the first cylinder, and the same length of stroke, but the cranks are set at right angles, as in ordinary locomotives; consequently, at the moment of the steam being passed into the second cylinder from the first, the piston of the second cylinder is at the commencement of its stroke.

The steam continues expanding in the two cylinders, until the first piston, A, has nearly completed its stroke, when the valve, G, shuts off the communication between the two cylinders, and the valve, D, opens the exhaust port, and communicates with the blast-pipe, L, discharging the steam remaining in the cylinder, A, to form the blast in the ordinary manner. The second piston, B, has then arrived nearly at half stroke, and contains nearly one half of the total quantity of steam originally admitted to the first cylinder; this steam is further expanded to the end of the stroke, and then discharged into the blast pipe, L, by the valve, E, opening the exhaust port.

The return stroke of both pistons is exactly similar to the foregoing, so that about $\frac{1}{2}$ cylinder full of high-pressure steam (or such other portion as may be desired) is supplied to the first cylinder at each stroke, and between $\frac{1}{2}$ and $\frac{2}{3}$rds of that steam is discharged at the pressure required to produce the blast, and the remainder of the steam is expanded down in the second cylinder, so as to give out all the available power remaining in it.

For the purpose of enabling the engine to exert an increased power,

if required, at the time of starting a train or otherwise, the slide valve, I, is inserted in the centre passage, F, to close the communication between the two cylinders for a short time when required; and the steam from the boiler is then admitted by a pipe and cock into the steam-chest of the second cylinder, B, which is then worked independently of the other cylinder, like an ordinary engine.

The comparative quantity of steam or of coke required to perform the same work in the several engines, under the circumstances stated above, is given by calculation as follows :—

Continuous Expansion Engine			. . . .	100
Ordinary Engine, cutting off at			$\frac{1}{3}$rd stroke . .	120
Ditto	ditto,	ditto	$\frac{1}{2}$ stroke . .	154
Ditto	ditto,	ditto	$\frac{2}{3}$rds stroke . .	185
Ditto	ditto,	ditto	$\frac{7}{8}$ths stroke . .	220

These figures represent the relative economy in the employment of the steam in the several engines; consequently, the ordinary Engine, with the best degree of expansion, or cutting off the steam at $\frac{1}{3}$rd of the stroke, consumes 20 per cent. more coke than the Continuous Expansion Engine, to do the same work, and from 54 to 85 per cent. more coke with the more usual degrees of expansion; and an Engine cutting off the steam at only $\frac{1}{8}$th of the stroke from the termination, as many engines were formerly made, would consume 120 per cent. more coke to do the same work.

This plan has been tried upon two locomotives with satisfactory results, and the blast was fonnd to be quite sufficient, but the trial has not been sufficiently complete to afford a definite comparison of consumption.

In the application of the Expansion principle to Stationary Engines, it is requisite to consider the amonnt of variation in the moving power or labouring force of the engine, and the limits within which it is necessary practically to confine this variation. The accompanying diagrams, Figs. 3, 4, and 5, Plate 53, show the variation in the moving power that takes place between the commencement and the end of the stroke in each of the several engines, all drawn to the same scale and on the same principle, so that the comparison of the diagrams will show

the relative effect of the steam in the several engines; the same total power being represented in each case.

Fig. 3 shows the variation of power in the Cornish engine, when the steam is expanded down to the limit of useful effect; this is shown by the curved line, A G C. The vertical height of the first division, A D, represents the relative total moving force developed by the engine, in the direction of the revolution of the crank pin, during the first 15° of revolution from the commencement of the stroke. The heights of the succeeding divisions in Fig. 3 represent the corresponding amounts of force developed by the engine during each successive motion of the crank, through equal angles of 15° each to the end of the stroke, C, and the half revolution of 180°; the force shown being in all cases the amount that would be produced in the circular direction of the revolution of the crank pin, not in the rectilinear direction of the piston. If the amounts of force in these several divisions were all exactly *equal to one another* (and the engine having attained its state of uniform velocity, were employed to overcome a constant resistance to circular motion, such as driving a corn mill or spinning mill, &c.), then the crank arm would have a perfectly unvarying velocity, and no fly-wheel would be required. And the approach to this constancy of velocity, in any engine applied to overcome resistances to circular motion, will clearly depend on the approach to equality which these amounts of work produced through equal angles make to one another.

The average line, DE, shows this average equal height of all the several divisions, consequently the rectangle, ACED, represents the equivalent uniform development of power that would produce an unvarying velocity of rotation, and therefore the area of the shaded space being the deficiency in filling up this rectangle of uniform power by the actual working of the engine (also equal to the portion H of the curved figure that is above the average line, DE), will represent the total amount of variation from the average in the moving force of the engine throughout the stroke. The area of the shaded portion in this diagram is 43 per cent. of the total area, consequently the *total variation* from the average in the moving power of the Cornish engine is 43 *per cent.*, and the *greatest variation* at the extreme point G, amounts to 189 *per cent.* of the mean power.

The total variation from the average power . 43 per cent.
The extreme variation . . . . 189 per cent.

Fig. 4 shows in a corresponding manner the variation of moving power throughout the stroke in the Continuous Expansion Engine, where the steam is cut off at half stroke in the first cylinder, and expanded in the larger cylinder down to the limit of useful effect.

The total variation from the average power is only . 13 per cent.
The extreme variation . . . . 55 per cent.
consequently the *total variation* in the moving power in the Cornish Engine is 3½ *times* as great as that in the Continuous Expansion Engine, and the *extreme variation* is 3½ *times* as great.

The dotted line, B B, in Fig. 3 shows the effect of coupling together two Cornish engines, exactly similar to that shown by the full line in Fig. 3, but of half the total power each.

The total variation from the average power is . . 20 per cent.
The extreme variation . . . . 58 per cent.
the *total variation* in the moving power being 1½ *times* as great as in the Continuous Expansion Engine, and the *extreme variation* about equal. This arrangement would of course be much more expensive than the Continuous Expansion Engine, as it involves two complete engines.

Fig. 5 shows the variation of moving power in a Woolf's double cylinder engine, where the pistons work simultaneously in the two cylinders, commencing each stroke together, and the steam is cut off at half stroke in the first cylinder, and afterwards expanded in the larger cylinder down to the limit of useful effect, as in the foregoing Cornish Engine.

The total variation from the average power is . . 27 per cent.
The extreme variation . . . . 90 per cent
consequently the *total variation* in the moving power is 2 *times* as great as in the Continuous Expansion Engine, and the *extreme variation* 1⅔ *times* as great.

The dotted line, F F, on Fig. 4 shows the effect of coupling together two of the Continuous Expansion Engines at right angles to each other, and the result of this arrangement is a remarkably near approach to perfect uniformity of moving power.

The total variation from the average power is only . 3 per cent.
The extreme variation . . . . 8 per cent.

The dotted line, F F, on Fig. 3 shows in a similar manner the effect of coupling together three of the Cornish Engines with cranks at 120° to each other.

The total variation from the average power is . . 9 per cent.

The extreme variation . . . . 22 per cent.

both being about 3 *times* as great as in the Continuous Expansion Engine.

Fig. 5 shows also by the dotted line, F F, the effect of coupling together two of the Woolf's Engines at right angles to each other.

The total variation from the average power is . . . 5 per cent.

The extreme variation . . . . 13 per cent.

both being about 1½ *times* as great as in the Continuous Expansion Engine.

The comparative amount of work performed by the several engines, with the same quantity of steam or of coal in each case, under the circumstances stated above, and taking the pressure of the steam admitted to the first cylinder at 50 lbs. per inch above the atmosphere, is given by calculation as follows :—

Continuous Expansion Engine	100
Woolf's Engine	109
Cornish Engine	111

The general result of the above comparisons is, that the *Cornish Engine is* 11 *per cent.*, and *Woolf's Engine is* 9 *per cent.*, *more economical* in expenditure of fuel than the *Continuous Expansion Engine*, when the expansion of the steam is carried to the *extreme limit* in each case; but that this economy cannot be obtained practically in those two engines, on account of the great irregularity in their moving power, the *average irregularity* being, in the *Cornish Engine* 30 *per cent.*, and in *Woolf's Engine* 14 *per cent.*, *greater* than in the Continuous Expansion Engine; and the *extreme irregularity* being 134 *and* 35 *per cent.* respectively *greater*.

Consequently it appears that, although the expansion of the steam cannot be *theoretically* carried to so great an extent in the Continuous Expansion Engine as in the other engines, yet, from the moving power being so much more uniform throughout the stroke, the expansion can be carried *practically* to a considerably greater extent; and a

greater amount of economy may be practically obtained within the same limit of uniformity in the moving power.

A working model, one third size, of the engine as applied to a Locomotive, was exhibited to the Meeting.

Mr. E. Jones observed that the engine appeared to be a step quite in the right direction, but further practical trial was requisite.

Mr. Peacock wished to know the particulars of the trials that had been made.

The Chairman suggested that the discussion should be adjourned to the next meeting, as Mr. Samuel, who had intended to be present, was unexpectedly prevented from attending. He proposed a vote of thanks to Mr. Samuel, which was passed.

The Chairman announced that Mr. Prosser, of Birmingham, had kindly sent, for the inspection of the Members, the portrait of Papin that was exhibited to the Meeting.

The Meeting then terminated; and in the evening a number of the Members and their friends dined together, according to custom, in celebration of the fifth Anniversary of the foundation of the Institution.

Mr. Geach announced that the Committee formed for carrying out the Monument to the late George Stephenson, had made final arrangements to erect a marble statue in the centre of the large entrance hall, at the Euston Station, as the metropolitan terminus of the system of railways of which he had been the originator. The Directors of the London and North Western Railway had kindly given their sanction to this proposal, which had met with general approval amongst the Subscribers, and the Committee had obtained subscriptions amply sufficient to carry out the intention. A very gratifying feature in the subscription was, the large number of working mechanics who had joined in promoting the object.

SUBJECTS FOR PAPERS.

STEAM ENGINE BOILERS, particulars of construction—form—heating surface—cost—consumption of fuel—evaporation of water—pressure of steam—steam gauges, high-pressure and low-pressure—explosion of boilers, and means of prevention—effects of heat on the metal of boilers, low-pressure and high-pressure—incrustation of boilers, and means of prevention—evaporative power and economy of different kinds of fuel, coal, wood, charcoal, peat, patent coal, and coke—moveable grates—smoke consuming apparatus, best plan and results of working.

STEAM ENGINES, expansive force of steam, and best means of using it—power obtained by various plans—comparison of double and single cylinder engines—comparative advantages of direct-acting and beam engines—indicator figures from engines, with details of useful effects, consumption of fuel, &c.—contributions of indicator figures for a general book of reference to be kept in the Institution.

PUMPING ENGINES, particulars of various constructions—size of cylinder, strokes per minute, and horse-power—number and size of pumps, and strokes per minute—application of pumps—fen draining engines—comparative advantages of scoop wheels and centrifugal pumps, &c.

BLAST ENGINES, best kind of engine—size of cylinder, strokes per minute, and horse-power—number of boilers—size of blowing cylinder, and strokes per minute—means of regulating the blast—improvements in blast cylinders—rotary blowing machines.

MARINE ENGINES, power of engines in proportion to tonnage—different constructions of engines—comparative economy and durability of different boilers, tubular boilers, flat flue boilers, &c.—weight of machinery and boilers—kind of paddle wheels—speed obtained in British war steamers, in British merchant steamers, and in Foreign ditto, with particulars of the construction of engines with paddle wheels, &c.—screw propellers, particulars of different kinds, number of arms, material, means for unshipping, horse-power applied, speed obtained, section of vessel.

ROTARY ENGINES, particulars of construction, and practical application—details of the results of working.

LOCOMOTIVE ENGINES, express, passenger, and luggage engines—particulars of construction, details of experiments, and results of working—speed of engines, cost, power, weight, steadiness—consumption of fuel—heating surface, length and diameter of tubes—experiments on size of tubes and blast-pipe—comparative expense of working and repairing—best make of pistons, valve gear, expansion gear, &c.

Caloric Engines, and Engines worked by Gas, Gun-cotton, or other explosive compounds.

Electro-Magnetic Engines, particulars and results.

Water Wheels, particulars of construction, and dimensions—form and depth of buckets—head of water, velocity, per-centage of power obtained—turbines, construction and practical application, power obtained, comparative effect and economy.

Wind Mills, particulars of construction—number of sails, surface and form of sails—velocity, and power obtained—average number of days' work per annum.

Corn Mills, particulars of improvements—power employed—application of steam power—results of working with an air blast and small stones—advantages of regularity of motion.

Sugar Mills, particulars of the construction and working—results of the application of the hydraulic press in place of rolls.

Saw Mills, particulars of construction—mode of driving—power employed—particulars of work done—best speeds for vertical and circular saws—form of saw teeth—saw mills for cutting ship timbers—veneer saws.

Oil Mills, facts relating to the construction and working, by stampers and by pressure.

Cotton Mills, information respecting the construction and arrangement of the machinery—power employed, and application of power—cotton presses, mode of construction and working, power employed—improvements in spinning and carding machinery, &c.

Machinery for manufacturing Flax, both in the natural length of staple and when cut.

Rolling Mills, improvements in machinery for making iron and steel—mode of applying power—steam hammers—piling of iron—plates—fancy sections.

Stamping and Coining Machinery, particulars of improvements, &c.

Paper Making and Paper Cutting Machines, ditto ditto.

Printing Machines, ditto ditto.

Calico Printing Machinery, ditto ditto.

Water Pumps, facts relating to the best construction, means of working, and application—best forms—velocity of piston—construction of valves.

Air Pumps, ditto ditto ditto.

Hydraulic Presses, facts relating to the best construction, means of working, and application.

Rotary and Centrifugal Pumps, ditto ditto.

Fire Engines, ditto ditto ditto.

Sluices and Sluice Cocks, ditto ditto ditto.

Cranes, ditto ditto ditto.

Steam Cranes, Hydraulic Cranes, Pneumatic Cranes, ditto.

Lifts for raising Trucks, &c. ditto ditto ditto.

Lathes, Planing, Boring, and Slotting Machines, &c., particulars of improvements—description of new self-acting tools.

TOOTHED WHEELS, best construction and form of teeth—results of working.

DRIVING BELTS AND STRAPS, best make and material, leather, rope, wire, gutta percha, &c.—comparative durability, and results of working—power communicated by certain sizes.

STRENGTH OF MATERIALS—facts relating to experiments on ditto, and general details of the proof of girders, &c.—girders of cast and wrought iron, particulars of different constructions, and experiments on them—best forms and proportions of girders for different purposes—best mixtures of metal.

DURABILITY OF TIMBER of various kinds—best plans for seasoning timber and cordage—results of Kyan's, Payne's, Bethell's, and Burnett's processes, &c.—comparative durability of timber in different situations.

CORROSION OF METALS by salt and fresh water, and by the atmosphere, &c.—facts relating to corrosion, and best means of prevention.

ALLOYS OF METALS—facts relating to different alloys.

FRICTION OF VARIOUS BODIES—facts relating to friction under ordinary circumstances—friction of iron, brass, copper, tin, wood, &c.—proportion of weight to rubbing surface—best forms of journals, and construction of axle-boxes, &c.—lubrication, best materials and means of application, and results of practical trials—best plans for oil tests.

IRON ROOFS, particulars of construction for different purposes—durability in various climates and situations—comparative cost, weight, and durability—roofs for slips of cast-iron, wrought iron, timber, &c., best construction, form, and material.

FIRE-PROOF BUILDINGS, particulars of construction—most efficient plan—results of trials.

CHIMNEY STACKS of large size, particulars, mode of building, &c.

BRICKS, manufacture and durability—hollow bricks, fire-bricks, and fire-clay.

GAS WORKS—best form, size, and material for retorts—construction of retort ovens—quantity and quality of gas from different coals—oil gas, water gas, &c.—improvements in purifiers, condensers, and gas holders—wet and dry gas meters—pressure of gas, gas exhauster—gas pipes, strength and durability, and construction of joints—proportionate diameter and length of gas mains, and velocity of the passage of gas—experiments on ditto, and on the friction of gas in mains, and loss of pressure.

WATER WORKS—facts relating to water works—application of power, and economy of working—proportionate diameter and length of pipes—experiments on the discharge of water from pipes, and friction through pipes—strength and durability of pipes, and construction of joints—relative advantages of stand-pipes and air-vessels.

WELL SINKING AND ARTESIAN WELLS, facts relating to.

COFFER DAMS AND PILING, facts relating to the construction:

PIERS, fixed and floating, and Pontoons, ditto ditto.

PILE-DRIVING APPARATUS, particulars of improvements—use of steam power—Pott's apparatus—the compressed air system.

DREDGING MACHINES, particulars of improvements—application of dredging machines—power required, and work done.

DIVING BELLS AND DIVING DRESSES, facts relating to the best construction.

CAST-IRON AND WROUGHT-IRON LIGHTHOUSES, ditto ditto.

MINING OPERATIONS, facts relating to mining—means of ventilating mines, use of steam jet and ventilating machinery—mode of raising materials—mode of breaking, pulverizing, and sifting various descriptions of ores.

BLASTING, facts relating to blasting under water, and blasting generally—use of gun cotton, &c.—effects produced by large and small charges of powder.

BLAST FURNACES—consumption of fuel in different kinds—burden, make, and quality of metal—pressure of blast—horse-power required—economy of working—improvements in manufacture of iron—comparative results of hot and cold blast.

PUDDLING FURNACES, best forms and construction, &c.

HEATING FURNACES, best construction—consumption of fuel, &c.

SMITHS' FORGES, best construction—size and material—power of blast.

SMITHS' FANS, and FANS generally, best construction, form of blades, &c., with facts relating to the amount of power employed and the per-centage of effect produced.

COKE AND CHARCOAL, particulars of the best mode of making, and construction of ovens, &c.

RAILWAYS—construction of permanent way—section of rails, and mode of manufacture—experiments on rails, deflection, deterioration, and comparative durability—material and form of sleepers, size and distances—improvements in chairs, keys, and joint fastenings.

SWITCHES and CROSSINGS, particulars of improvements, and results of working—advantages obtained by steeling points and tongues.

TURNTABLES, particulars of various constructions and improvements.

SIGNALS for Stations and Trains, and self-acting signals.

BREAKS for Carriages and Waggons, best construction.

BUFFERS for Carriages, &c., and Station Buffers—different construction and materials.

SPRINGS for Carriages, &c., buffing and bearing springs—particulars of different constructions, and results of working.

RAILWAY WHEELS, wrought-iron, cast-iron, and wood—particulars of different constructions, and results of working—comparative expense and durability—wrought-iron and steel tires, comparative economy and results of working—solid wrought-iron wheels.

RAILWAY AXLES, best description, form, material, and mode of manufacture—comparison of solid and hollow axles.

The Council invite communications from the Members and their friends on the preceeding subjects, and on any Engineering subjects that will be useful and interesting to the Institution;—also presentations of Engineering drawings, models, and books for the library of the Institution.

The communications should be written on foolscap paper, on one side only of each page, leaving a clear margin on the left side for binding; they should be written in the third person. The drawings illustrating the communications should be on so large a scale as to be clearly visible to the meeting at the time of reading the communication; or enlarged diagrams should be sent for the illustration of any particular portions.

INSTITUTION OF MECHANICAL ENGINEERS.

BALANCE SHEET,

For the year ending 31*st December*, 1851.

Dr.	£	s.	d.
To Subscriptions from 16 old Members in Arrear	48	0	0
„ ditto from 152 old Members for 1851	456	0	0
„ ditto from 19 new Members for 1851	95	0	0
„ ditto from 3 old Graduates for 1851	6	0	0
„ ditto from 1 new Graduate for 1851	3	0	0
„ ditto from 1 Member in advance for 1852	3	0	0
„ sale of Extra Engravings	3	3	0
„ ditto ditto Reports	5	12	3
„ Balance from 31st December, 1850	230	3	0
	£849	18	3

Cr.	£	s.	d.
By Printing, Engraving, and Stationery	96	16	7
„ Furniture for Offices	12	11	7
„ Office Expenses and Petty Disbursements	15	18	8
„ Travelling Expenses	8	9	3
„ Reporting	17	3	0
„ Parcels	4	6	0
„ Postages	26	0	5
„ Salary	343	15	0
„ Rent and Taxes	122	2	7
„ Balance	202	15	2
	£849	18	3

(Signed) J. E. CLIFT.
ARCHIBALD SLATE.

26th January, 1852.

INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

HELD IN BIRMINGHAM, ON 28TH APRIL, 1852.

ROBERT STEPHENSON, ESQ., M.P., PRESIDENT,

IN THE CHAIR.

BIRMINGHAM:

PRINTED AT M. BILLING'S STEAM-PRESS OFFICES,

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1852.

PROCEEDINGS.

The General Meeting of the Members was held at the house of the Institution, 54, Newhall Street, Birmingham, on Wednesday, 28th April, 1852; Robert Stephenson, Esq., M.P., President, in the Chair.

The Minutes of the last General Meeting were read and confirmed.

The Chairman announced that the Ballot papers had been opened by the Committee appointed for the purpose, and the following new Members were duly elected:—

Members:

Thomas T. Chellingworth, Oldbury.
Samuel H. F. Cox, Oldbury.
Robert Gordon, Stockport.
John H. Porter, Birmingham.
Joseph W. Wilson, Oldbury.
William K. Whytehead, London.

Honorary Member:

William Robinson, Birmingham.

The following supplementary paper, by Mr. James Samuel, of London, was then read, in continuation of the paper read at the former Meeting, on January 28th, and adjourned:—

ON A CONTINUOUS EXPANSION STEAM ENGINE.

The object of this invention, as applied to Locomotive Engines, (as explained in detail in the former paper, see Proceedings,

January, 1852,) is to obtain a greater amount of work from the same expenditure of steam or fuel than could be obtained from the present locomotive engines. It was pointed out that the extent to which the expansion of the steam could be carried was limited in the present locomotives, by the necessity of maintaining a certain amount of pressure in the steam at the moment of discharging it into the atmosphere, for the purpose of producing an *efficient blast* to maintain the intensity of the fire. If it were not for this circumstance, which prevented the expansion of the steam being carried in the cylinders beyond about 30lbs. per inch above the atmosphere, the expansion might be continued nearly down to the atmosphere, and most of the 30lbs. so lost would be then made available as additional power obtained from the same steam. But the author of the paper had found, from experiments, that in the ordinary working, a portion of the discharged steam, probably as much as one-half, could be *spared from the blast*, provided the remainder was discharged at the full pressure of 30lbs., and he therefore retained that portion of the steam in his engine, and caused it to expand nearly down to the atmospheric pressure before it was discharged. This was accomplished by admitting the steam from the boiler only to one of the cylinders of the locomotive, where it was cut off at about half stroke, at which point the second cylinder was just commencing its stroke, (the two cranks being at right angles, as usual,) and a communication was then opened by the slide valve with the second cylinder, which was made from two to three times the area of the first cylinder. The steam was then expanded in both cylinders simultaneously, until the communication between them was closed, and the steam in the first cylinder was discharged as the blast, whilst that in the second cylinder, which had still half its stroke to perform, was further expanded down to the lowest point of efficiency. By this means, it was shown, a saving in consumption of steam and fuel of 20 per cent. would be effected, compared with the most economical working that could be maintained practically in the present engines, to perform the same work; whilst it would require 120 per cent. more fuel to do the same work with an engine that did not work expansively, and only cut off the steam at one inch from the end of the stroke, as many locomotives were formerly

made. By the second cylinder being enlarged in area in proportion to the difference of average pressure, each cylinder exerted the same total moving power upon its crank, as in the ordinary engines, so that no practical difficulty was experienced; and the steam from the boiler could be admitted direct to the second cylinder by a stop valve for a short time, when required, to give an increased power at starting, or ascending inclines. Two practical trials had been made, which showed that the engines were not deficient in steam from the alteration of the blast, although working the regular passenger and goods trains at full speed. There had not been yet an opportunity for making sufficiently complete experiments to prove the relative economy, but the consumption of fuel was found to contrast favourably with the ordinary engines.

An accurate comparison of the relative amount of duty obtained from the same quantity of steam when employed in these different engines, is shown by the approximate Indicator diagrams, Figs. 1, 2, and 3, Plate 54. which have been carefully drawn out from comparison with actual indicator diagrams, taken from locomotives, so as to allow correctly for the pressure of the exhaust and compression, and the wiredrawing of the valve.

Fig. 2 shows the performance of the steam in an Ordinary Engine, with two 15-inch cylinders = 353·4 square inches area, and 24-inch stroke, cutting off the steam at 8 inches, or ⅓rd of the stroke, at A. The pressure of the steam is 100 lbs. per inch above the atmosphere, but reduced by wiredrawing to 92 lbs. at the point of cutting off, so that the dotted line A B represents the actual quantity of steam supplied to the two cylinders for one stroke, being 353·4 × 8 inches = 2827 cub. in. at 92 lbs. per inch.

In this case, and in the other two diagrams, the compression C has been made exactly sufficient to fill up the ports and clearance entirely to the full pressure of 92 lbs. steam, for the purpose of simplifying the comparison without interfering with the correctness of the result, so that the steam consumed in each case is exactly equal to the extent of motion of the piston to the point of cutting off the steam.

The steam is exhausted at D, having been expanded down to 28 lbs. above the atmosphere, at which pressure it is discharged as the blast.

The back pressure E is taken at 5lbs. per inch at full speed—say forty miles per hour, from the end of the exhaust to the beginning of compression.

The average positive pressure throughout the stroke	=	63·3 lbs.
„ „ negative „ „	„	10·1 lbs.
Total effective pressure . . .		53·2 lbs.

Total Power = 353·4 in. area × 53·2 lbs. per inch = 18,801

Fig. 1 shows the performance of the same steam (2827 cub. in. at 92lbs. per in.) in the Continuous Expansion Engine; the first cylinder is 147·8 sq. in. area,(or about 13¾ in. diameter,) and the second cylinder is three times the area = 443·4 sq. in. area (or about 23¾ in. diameter,) both being 24-inch stroke, the same as before. The steam is cut off at A, at 16½ inches, or about ⅔rds of the stroke of the small cylinder, and at D at 1 inch of the stroke of the large cylinder. The dotted lines AB and D, added together, represent the total quantity of steam admitted in each stroke, being equal to the line AB in Fig. 2.

The steam is expanded in both cylinders down to 30 lbs. per inch at the points E and F, 2 inches from the middle of the stroke of the large cylinder, when the communication is shut between the two cylinders, and the steam in the first cylinder is discharged as the blast, amounting to 44 per cent of the whole quantity of steam admitted, and at the pressure of 30lbs.; being a little higher than the pressure of the blast taken in the ordinary engine, Fig. 2, and about half the quantity of steam.

The back pressure G in the small cylinder is taken at 5lbs. per inch, the same as in Fig. 2; but the steam in the second cylinder is further expanded down to 7lbs. per inch above the atmosphere before it is exhausted at H, and reduced nearly to the atmospheric pressure at the end of the stroke, the back pressure I being taken at ½lb. per inch.

		Small Cylinder.	Large Cylinder.
The average positive pressure throughout the stroke	=	87·2lbs.	30·8lbs.
Ditto negative ditto ditto	=	13·8lbs.	4·9lbs.
Total effective pressure . .		73·4lbs.	25·9lbs.

Total Power,

1st cylinder, 147·8 in. area × 73·4lbs. per inch	= 10,849
2nd cylinder, 443·4 in. area × 25·9lbs. per inch	= 11,484
Total . . .	22,333

Then 18,801 : 22,333 : : 100 : 119

Therefore Gain = 19 per cent.

Consequently the power obtained in the Continuous Expansion Engine, or the total shaded area of the Indicator diagrams, Fig. 1, is 19 *per cent. greater* than the power obtained from the *same steam* when employed in the Ordinary Engine, or the shaded area of the diagram Fig. 2, when the expansion is carried as far as appears to be found practicable, consistently with the maintenance of a sufficient pressure of blast.

Fig. 3 shows the power obtained from the same quantity of steam in a Non-Expansive Engine when the steam is not cut off until 1 inch from the end of the 24 inch stroke; the cylinder is then about 122·9 sq. in. area (or about 12½ inches diameter), containing the same quantity of steam (2827 cub. in., at 92lbs. per in.) in 23 inches of the stroke, where it is cut off at A, the dotted line AB being the same length as in the previous diagrams.

The back pressure G is taken at the same, 5lbs. per inch, as in the first case.

The average positive pressure throughout the stroke	= 97·0lbs.
Ditto negative ditto ditto	= 14·4lbs.
Total effective pressure . .	82·6lbs.
Total Power = 122·9 in. area × 82·9lbs. per inch .	= 10,151

Then 10,151 : 22,333 : 100 : 220

Therefore Gain = 120 per cent.

of the Continuous Expansion Engine compared to a Non-Expansive Engine.

In the Continuous Expansion Engine, although the second cylinder is three times the contents of the first cylinder, the average pressure is about one-third, being 25·9lbs. compared to 73·4lbs., so that the total propelling power of each of the cylinders is very nearly equal, as in an ordinary engine, and no practical objection is occasioned.

The application of the principle to *Stationary Engines* was described in the former paper, and it was shown to be a means of carrying the expansive principle to a greater extent than is practicable in the present engines, thereby proving an important source of economy, because of the great uniformity in the combined moving power of the two cylinders as exerted upon the crank shaft in a rotary direction, on account of the cranks being at right angles, and the continuous expansion of the steam in the two cylinders: but in ordinary engines the expansion could not be carried so far, where uniformity of motion was requisite, as in driving machinery, because of the great irregularity in the rotary power that was produced when the expansion was carried far.

The comparative effects were shown by a series of diagrams, of the variations in the total amount of moving power, or labouring force, exerted in the direction of the rotary motion of the crank, in the Continuous Expansion Engine, in Woolf's Double-Cylinder Engine, and in the Cornish Engine, taking the steam in each case to be admitted at 50lbs. per inch above the atmosphere, and expanded down to the lowest useful pressure before it is condensed. The following comparative results were obtained :—

	Continuous Expansion Engine.		Woolf's Engine.		Cornish Engine.
Average amount of irregularity in moving power, throughout each stroke . . .	100	—	114	—	130
Extreme irregularity during the stroke . .	100	—	135	—	234
Comparative amount of work done by the same steam or fuel	100	—	109	—	111

The general results of these comparisons being, that the *Cornish Engine is* 11 *per cent.*, and *Woolf's Engine is* 9 *per cent. more economical* in expenditure of fuel than the *Continuous Expansion Engine*, when the expansion of the steam is carried to the *extreme limit* in each case; but that this economy cannot be obtained practically in those two engines, on account of the great irregularity in their moving power,—the *average irregularity* being in the *Cornish Engine* 30 *per cent.*, and in *Woolf's Engine* 14 *per cent. greater* than in the Continuous Expansion Engine; and the *extreme irregularity* being 134 *and* 35 *per cent.* respectively *greater*.

Consequently it appears that, although the expansion of the steam cannot be *theoretically* carried to so great an extent in the Continuous Expansion Engine as in the other two engines;—yet from the moving power being so much more uniform throughout the stroke, the expansion can be carried *practically* to a considerably greater extent; and a greater amount of economy may be practically obtained within the same *limit of uniformity* in the moving power.

The comparison between the Continuous Expansion Engine and an ordinary Non-Expansive Condensing Engine, in which the steam exerts a uniform pressure upon the piston, from the commencement to the end of the stroke, shows that the variation in the development of moving power throughout one revolution, is in the former case only 43 *per cent.*, and in the latter, 62 *per cent.*, extreme variation from the average power.

The relative economy of the two Engines, or the amount of duty obtained from the expenditure of the same quantity of fuel in each case is as 100 to 38; so that the Continuous Expansion Engine does the same work as the Non-Expansive Engine, with a more uniform moving power, and with 62 per cent. less fuel.

The CHAIRMAN observed, that the subject of the paper was interesting and important, and it was well deserving of a thorough

investigation. He enquired whether any indicator cards had been taken from the engines that were altered, to show the actual results?

Mr. Samuel replied, that the trials made were incomplete, and he had not had an opportunity of taking indicator diagrams from the engines, nor of carrying out the trials sufficiently to obtain comprehensive results suitable for laying before the Institution. One of the engines tried was a Goods Engine of the largest size, on the Eastern Counties Railway; the valves only were altered, and the second cylinder was not enlarged. It was only a temporary experiment, which of course caused a reduction in the extreme power that the engine could exert, and the object was more particularly to see how the principle could be best carried out in practice, and whether the proposed reduction in the blast could be effected; the result was a saving of 12 lbs. of coke per mile in consumption.

The Chairman remarked, that the steam was only supplied to one cylinder instead of two, and therefore so much less consumption of steam would take place.

Mr. Samuel explained, that the engine did the same usual work during the trial as before; the engine-driver could work the engine in the ordinary manner up the inclines, by shutting the communication between the two cylinders, or the engine could not probably have taken the load through the trip, but he might be using more steam than usual in the one cylinder by keeping the regulator more open.

Mr. E. Jones thought the proposed plan deserved having careful experiments tried: the diagrams shown were theoretical, and might mislead in the practical results, and he could not say how far they would agree with actual indicator diagrams, and he hoped a full trial would be made of the engine.

The Chairman considered it very desirable that the principle should be fairly tried; it seemed a good idea, and well worth being thoroughly worked out.

Mr. McConnell observed, that he had doubts whether an

engine at considerable speed, using much steam, would get a sufficient blast if altered in the proposed manner, and would not require the blast-pipe to be reduced, involving a loss of power from that cause.

Mr. Samuel replied, that in the two engines that had been tried no difficulty appeared in making steam, and they were not found short of steam. Goods engines working at slow speed might perhaps be found the most useful cases for applying the principle. The other engine that had been tried was a passenger engine, in which the second cylinder was made double the area of the first; and it was never found short of steam, though running an express train of considerable weight. The results of the experiments as to economy were interfered with by a defect in the construction of the valves, which were tried with india-rubber packing at the back, as equilibrium valves, and proved leaky in working; and there was not an opportunity of carrying out the experiment further with valves of the ordinary kind, so that no sufficient results were obtained as to consumption, though as long as the valves remained in order the engine contrasted favourably in consumption with other engines of the same class and work. The only definite result obtained was with respect to the sufficiency of the blast, which proved quite satisfactory during the regular passenger train work of about a month.

Mr. McConnell thought there would be an advantage in the relative consumption of fuel, from the engine employing less steam with the same boiler, as he considered it was an important source of economy of fuel to increase the heating surface in proportion to the consumption of the cylinders, particularly in the large goods engines.

The Chairman observed, there was some uncertainty from the form of the experiment whether the economy observed was due to an improved mode of employing the steam, or was caused by not over-working the boiler; if less work was performed by the engine, then less steam was wanted from the boiler in the

same time, and the smaller quantity of steam would be generated more economically from the same firegrate and heating surface.

Mr. McConnell remarked, that great care would be required in setting the valves, to insure the proper action of the steam in the two cylinders; and it would be more important than in the case of the ordinary slide-valves, for the valve-gearing to be kept in perfect adjustment.

Mr. D. K. Clark (of Edinburgh) observed, in reference to the correctness of the conclusions to be drawn from the artificial indicator diagrams that were exhibited, that although they were artificial, they were founded on actual diagrams taken from locomotive engines, and therefore legitimate conclusions could be derived from them, and he considered they might be relied upon. The back pressure in the second cylinder, where there was no blast, had been taken in the diagram at only half-pound per inch, and would, of course, require to be matter of experiment to prove it positively; but he had observed the back pressure as low in locomotives where the valves and ports were properly adjusted; and in the diagram, taken from the Great Britain engine, at fifty-five miles per hour (which was before the Meeting), the back pressure was less than half-pound, with a blast pipe, when the steam was cut off at one-third of the stroke.

It had been assumed in the paper, that the steam could not be cut off in practice at less than one-third of the stroke, on account of the blast, but he had found it cut off at only one-fifth of the stroke in engines on the Caledonian Railway, and even less: still they worked well and appeared to make steam enough; but then it was certainly down the heavy inclines where the consumption of steam was small.

The Chairman said there was one novel circumstance in the arrangement of the proposed engine, which did not appear correct in theory: in all the previous double-cylinder engines, the first piston was allowed to complete its stroke before the steam was expanded into the second cylinder, but in this engine

the steam is passed into the second cylinder at the middle of the stroke of the first piston, thereby taking the steam away at the very moment that it is most efficient in the small cylinder.

Mr. SAMUEL explained, that at the half stroke of the first piston, the second piston was at its dead point, and began to move very slowly when the communication was opened between the two cylinders, and consequently took very little steam whilst the first piston moved through the greater portion of its remaining stroke; but then, as the first piston was getting less effective and approached its dead point, the second piston came gradually into full action, making a *continuous* expansive action, which was the peculiar feature of this engine, instead of the *intermittent* expansion of the other double-cylinder engines. This was borne out by the diagram, (Fig. 1,) showing a nearly continuous line of expansion (D F H) from beginning to end of the stroke; and the great uniformity in the total moving power of the two cylinders was shown in the former diagram, (Plate 53.)

Mr. SLATE wished some complete experiments should be made on the practical effect of expansion; he was doubtful whether so much of the theoretical advantage could be obtained in practice as had been supposed. In the present engine he could not understand the advantage of employing part of the steam at a lower pressure in a larger cylinder, as he thought that would cause the constant resistance of the atmosphere to be more seriously felt. If the strain were employed at the full pressure, say 90lbs., in the small cylinder alone, the atmospheric resistance would only cause a deduction of one-seventh of the whole power; but if the strain were only at about 30lbs. pressure in the large cylinder, this deduction for the atmospheric resistance would be increased to one-third of the power. Therefore it appeared to him most advantageous to employ the steam only in the small cylinder, to diminish the proportion of atmospheric resistance as much as possible. He thought the diagrams given, though borne out by the results of calculation, could not

be argued from like actual indicator diagrams taken from the engine, and it was very desirable for those to be obtained.

Mr. Samuel said he had given the best information that he was able to furnish at present respecting the engine, and wished he could have supplied more practical results. He fully agreed on the importance of a thorough practical trial, and hoped that he had brought the importance of the subject sufficiently before the members to induce such of them as had the opportunity to give it a complete trial.

The Chairman remarked, that the pressure of the steam during expansion would be affected by the condensation that always took place to a considerable extent in the cylinder, and the expansion curve in the theoretical diagrams would consequently require practical correction for the condensation and temperature. There appeared to be always some condensation produced when steam was expanded.

Mr. Cowper thought the expansion curve could be practically laid down from Pambour's experiments, as the actual deviation in practice from the theoretical rate of expansion was very little. He thought there would not be found to be any loss by condensation in a well-protected cylinder; he had not found any condensation to take place in the experiments that he had tried on expansion.

The Chairman said he had always found a condensation take place in expanding steam, and he considered that the heat in steam was not sufficient to maintain all the steam in a gaseous state during expansion; and a portion of it was consequently condensed.

A vote of thanks was then passed to Mr. Samuel for his communication.

The following paper, by Mr. John Wilson, of Bridgewater Works, St. Helens, was then read:—

ON A NEW MODE OF MEASURING HIGH TEMPERATURES.

Several methods have been proposed for the measurement of temperatures beyond the range of the Mercurial Thermometer.

Wedgwood's Pyrometer was founded on the property which *clay* possesses of contracting at high temperatures. This effect, which in the first instance is due to the dissipation of the water, but afterwards to the partial vitrification occurring, which tends to bring the particles of clay into nearer proximity—may in some measure be regarded as an indication of the temperature which occasioned the contraction.

The apparatus consisted of a metallic groove, 24 inches long, the sides of which converged, being half-an-inch wide above and three-tenths below. The clay was made up into little cylinders or truncated cones, which fitted the commencement of the groove after having been heated to redness; and their subsequent contraction by heat was determined by allowing them to slide from the top of the groove downwards till they arrived at a part of it through which they could not pass. Wedgwood divided the whole length of the groove into 240 degrees, each of which he supposed equal to 130° of Fahrenheit, and he fixed the *zero* of his scale at the 1077th degree of Fahrenheit's Thermometer.

"Wedgwood's Pyrometer is no longer employed by scientific men, because its indications cannot be relied on. Every observation requires a separate piece of clay, and the experimenter is never sure that the contraction of the second piece from the same heat will be exactly similar to that of the first, especially as it is difficult to procure specimens of the earth the composition of which is in every respect the same. Hence also the different results obtained by different observers; Guyton de Morveau making each degree to correspond to 62½° of Fahrenheit, instead of 130° as stated by Wedgwood."—(*Turner's Chemistry.*)

Daniell's Pyrometer.—In the Pyrometer invented by the late

Professor Daniell, the temperature is measured by the expansion of an *iron* bar enclosed in a case. This case consists of a bar of black-lead earthenware, in which is drilled a hole, $\frac{3}{10}$ths of an inch in diameter, and 7½ inches deep. Into this hole a cylindrical bar of platinum or soft iron, of nearly the same diameter, and 6½ inches long, is introduced so as to rest against the solid end of the hole: and upon the outer or free end of the metallic bar rests a cylindrical piece of porcelain called the *index*, 1½ inches long, which is kept firmly fixed in its place by a strap of platinum and a little wedge of earthenware. The object of this arrangement is, that when the instrument is heated, the metal, expanding at each temperature more than the earthenware case, presses forward the index, which, in consequence of the strap and wedge, remains in the place to which it had been forced when the instrument is removed from the fire and cooled. There is a *scale*, afterwards attached, for measuring the precise extent to which the index has been pushed forward by the metallic bar; and it thus indicates the apparent elongation of the bar, that is, the difference between its elongation and that of the black-lead case which contains it. "For its indications to be correct, (namely, that equal dilatations should indicate equal increments of heat), it is necessary that the bar and the case should expand uniformly, or both vary at the same rate. But as regards the black-lead case, its total expansion is so very small that any want of uniformity at the intermediate points cannot be detected. As for the expansions of the metallic bar, these are not exactly uniform, but still they afford a good practical index of the relative intensity of different fires, and would be an exact measure, if the precise rate of expansion could be determined."—(*Turner's Chemistry*.)

Air Pyrometer.—In some cases the measurement of high temperatures has been attempted by means of a hollow sphere of platinum, fitted with an escape tube; then the hotter the fire to which the platinum vessel is exposed, the greater is the quantity of *air* driven out of it; and this is received over water and measured. In cases where this instrument can be conveniently applied, it is capable of yielding very accurate results. (See experiments of Pouillet, tome 1, p. 351, in *Elemens de Physique et de Météorologie*.)

New Pyrometer.—The following is the method employed by the author of the present paper to measure high temperatures. Take a given weight of *platinum*, and expose it for a few minutes to the fire the temperature of which is to be measured, and then plunge it into a vessel containing *water* of a determined weight and temperature, and after the heat has been communicated to the water by the heated platinum, mark the temperature which the water has attained: and from this is estimated the temperature to which the platinum had been subjected. Thus, if the piece of platinum employed be 1000 grains, and the water into which it is plunged be 2000 grains, and its temperature 60°, should the heated platinum when dropped into the water raise its temperature to 90°, then 90°—60°=30°; which, multiplied by 2, (because the water is twice the weight of the platinum,) gives 60°, that an equal weight of water would have been raised. Again; should the water in another case gain 40°, then 40° × 2 = 80°, denotes the temperature as measured by the pyrometer. To convert the degrees of this instrument into degrees of Fahrenheit, we must multiply by 31·25, or 31¼. Thus, 80° × 31¼, would give 2500° of Fahrenheit. And 60° × 31¼ = 1875°.

The multiplier 31·25 is the number expressing the *specific heat* of water as compared with that of platinum, the latter being regarded as 1.

In order to obtain very accurate results by this method, precautions similar to those required in determining the specific heat of bodies must be taken; that is, it is necessary to guard against the dissipation of heat by conduction and radiation. The apparatus used by the author is shown in Figs. 2 and 3, Plate 55, and consists of a polished tinned iron vessel, of a cylindrical form, 3 inches deep and 2 inches in diameter; this is placed within a concentric cylinder, separated from the enclosed vessel about ¼ inch. By this means there is but little heat lost during the experiment, either by radiation or conduction.

At the commencement of the experiments, the author imagined it would be necessary to employ a considerable proportion of water, and therefore took twenty-five times the weight of the platinum; but he found that the temperature gained by the water, even in

cases of very high heats, did not exceed 4° or 5°, and an error of 1°, when converted into degrees of Fahrenheit, amounted to 400°. To obtain results within much narrower limits of error, it became obvious, a much smaller proportion of water should be employed; and ultimately it was found that *double* the weight of the platinum was in all cases sufficient.

There is no appreciable loss of heat from the evaporation of steam when the hot platinum is plunged into the water;—there is probably no actual contact with the water until the platinum is fairly at the bottom of the water. It is in fact the converse of dropping water on a plate of platinum or iron *strongly* heated, in which case the water, instead of being suddenly dissipated as steam. assumes the spheroidal form, and runs about over the plate without coming in contact with the heated surface. It is only when the temperature of the metal becomes much reduced that the water is rapidly converted into vapour.

But whatever may be thought of this theory of contact, the fact is certain, that there is no necessity to increase the depth of the vessel of water to guard against the loss of heat by evaporation, or the escape of any bubbles of steam.

In ascertaining temperatures by this Pyrometer, a correction has to be made for the portion of the total heat that is absorbed by

1st, the mercury of the thermometer in the water;
2nd, the glass bulb and stem of the thermometer;
3rd, the iron vessel containing the water;
4th, the heat retained by the piece of platinum.

The portion of the total heat that is absorbed by these several bodies, compared to the portion received by the water, will be in proportion to their several weights, and the specific heat of each compared with water.

Mercury . .	200	grains	× $\frac{1}{30}$th	specific heat=	7	equivalent grains of water.
Glass . . .	35	„	× $\frac{1}{6}$th	„	6	„
Iron	658	„	× $\frac{1}{9}$th	„	73	„
Platinum .	1000	„	× $\frac{1}{32}$nd	„	31	„
				Total . . .	117	

Therefore the effect of these bodies is equivalent to the addition of 117 grains to the 2000 grains of water, or $\frac{1}{17}$th has to be added as a correction to all the temperatures obtained by this instrument; or in other words, the multiplier must be increased from 31¼ to 33 in this instrument, and in all similar ones where the weights of the mercury and glass of the thermometer, and of the iron vessel, are the same as stated above.

The following are some of the results obtained by this new Pyrometer.

In the experiments to which they refer, the melting points were ascertained by placing about two ounces of the metal in a cupel placed by the side of another cupel containing the piece of platinum;—the moment that the metal became fluid, the platinum was withdrawn, and the temperature measured as before described. It is necessary to avoid contact between the platinum and the melted body, for in some cases an alloy would be formed, and in others a portion of the melted substance would adhere to the platinum and affect the results; the closest proximity is requisite, but *contact* must be avoided. In lifting the piece of platinum, a pair of tongs is employed *heated to redness*, to prevent any abstraction of heat during the momentary contact.

TEMPERATURES OF MELTING POINTS IN DEGREES OF FAHRENHEIT.

	Wilson, with New Pyrometer.	Pouillet, with Air Pyrometer.	Daniell, with Iron Pyrometer.
Silver	1890°	1832°	1873°
Copper	2220°	——	1996°
Grey Cast Iron	2320°	2210°	2780°
Copper-smelting Furnace	3128°	——	——
Crown Glass	2244°	——	——
Flint Glass	2145°	——	——
Copper Slag	2046°	——	——

As the piece of *platinum* is the most expensive part of the apparatus, it is proposed that for practical purposes generally, a small piece of *baked Stourbridge clay* be substituted for the platinum;

and the author has found by experiment, that a piece of Stourbridge clay, 200 grains in weight, when heated to the melting point of *silver*, and then plunged into the tinned vessel containing 2000 grains of water, raises the temperature of the water 41°.

Now if 1890° Fahrenheit, (the melting point of silver found before,) be divided by 41, we obtain 46° as the number corresponding to 1° of this pyrometer; and 46 will therefore be the correct multiplier, and no corrections are required for any heat abstracted by the thermometer, the tinned vessel, or the piece of clay.

The temperature of all sorts of furnaces and flues of steam-engines, &c., may be readily ascertained by means of the piece of Stourbridge clay.

Mr. Wilson exhibited his new instrument, and showed the mode of using it.

The Chairman expressed the interest he felt in this new pyrometer that had been brought before the meeting, and considered it an ingenious and efficient instrument. He remembered having a conversation with the late Professor Daniell on the subject of his pyrometer, and expressing a doubt of the nearness of the approximation in the results obtained from that instrument; in fact, such delicate manipulation was required in using it, that it was scarcely available except in the hands of the inventor himself. But Mr. Wilson's instrument was so extremely simple in the construction and practical application, that an accurate measure of the quantity of heat could be relied upon, with ordinary care in the employment of the instrument.

It might be theoretically considered, that *quantity* of heat was a different point from *intensity* of heat, as in the case of voltaic electricity, the difference between quantity and intensity was known to be so strongly marked in the different effects produced; and this pyrometer, although measuring correctly the relative quantity of heat required to melt different bodies, might give far from a correct measure of the relative intensity

of different fires. However, the same theoretical question applied of course to the ordinary mercurial thermometer, which was also the standard of measure in this pyrometer, and to all thermometers which measured the degree of heat by the relative expansion of any body by heat, whether mercury, iron, or air. He inquired whether Mr. Wilson had tried the temperatures of any furnaces and flues with his pyrometer?

Mr. Wilson replied that he had not had an opportunity at present of making experiments on the temperature of furnaces, &c., but hoped to do so shortly. He proposed to employ the pieces of Stourbridge clay for this purpose, and to carry the piece of clay in a small bowl or hollow at the end of an iron rod, which could be readily introduced into the flue through a small hole in the side, and after being left there as long as required to insure the full temperature being attained, the iron rod could be withdrawn and the piece of clay dropped instantly into the vessel of water, without being touched by any other body.

Mr. Clift enquired whether the pieces of clay could be used more than once, on account of cracking when plunged into the water: and whether there was not a difficulty in obtaining them sufficiently uniform in composition and in specific heat to afford a correct measure?

Mr. Wilson replied that he had not found any difficulty in using the pieces of clay, and had used the same piece as many as eight times without any change, and he expected it would do for a hundred times. It was only requisite to obtain ordinary pure clay, and to have the pieces well fired. The pieces should not exceed the size shown, half-an-inch in thickness, to ensure the clay being uniformly heated throughout, as it was so slow a conductor of heat.

The Chairman suggested that, as a check upon its accuracy, the pyrometer should be tried with lead and some other metals of which the melting points were already accurately ascertained, being within the range of the mercurial thermometer.

Mr. Wilson said he had tried it with zinc, but not with

lead. He remarked, that any body might be employed for the construction of a pyrometer on this principle, by measuring its relative weight compared with the water, provided that its specific heat was correctly known. But it was necessary to observe that in measuring the melting point of bodies, the temperature must be taken just before melting takes place, because at the moment of liquefaction a certain quantity of latent heat was absorbed, as in the case of ice being melted into water; and beyond that point the temperature of the melted metal might rise considerably, and make the observation incorrect. In the case of the melting point of silver, he had found an error of 400° was caused when this was not attended to.

The results obtained by this pyrometer could not be regarded as *absolutely* correct, since the specific heat of platinum is assumed as constant at all temperatures, which is not strictly true. Nevertheless, these results are quite as near approximations to perfect accuracy as those given by the common mercurial thermometer, and all other instruments of the kind founded on the principle of expansion; for the variations in the rate of dilation at different temperatures are quite as great as the variations in the specific heat of a body.

The CHAIRMAN proposed a vote of thanks to Mr. Wilson, for his interesting and valuable communication, which was passed.

The following paper, by Mr. Daniel K. Clark, of Edinburgh, was then read:—

ON THE EXPANSIVE WORKING OF STEAM IN LOCOMOTIVES.

The opinions as well as the practice of Engineers on the working of Steam expansively in Steam engines, have been, and still are, at variance. Though many are disposed to grant that

there may be under certain conditions a sensible economy of steam when worked expansively, they have no durable faith in the principle, and consequently in their practice they do not concern themselves with the provisions which are essential to its success. In locomotives this want of confidence is conspicuous, for in many of them, as will be shown, the most obvious conditions of success in the employment of steam expansively, are overlooked in their design and arrangement. The opinion has been recently placed on record, in reference to expansive working in locomotives, that "it seems very doubtful in theory, and the results of practice would seem to confirm this view, whether any real advantage is gained by the so-called expansive working." In coming to this conclusion, however, it was assumed that the steam has a comparatively low average pressure in the cylinder at high speeds. In such circumstances the benefit would be proportionally limited; but this is a very partial view of the question, as the reduction of pressure at high speeds is merely incidental to defective proportions.

This leads to the first grand defect in the general design of locomotives—the adoption of a low standard of steam pressure in the boiler. The more expansively the steam is worked in a given cylinder, the less is the effective mean pressure on the piston, and the less is the work done by the engine. It therefore happens in many cases that the liberty of working expansively is limited by the necessity for a sufficiency of power to do the work required; and that in the performance of ordinary work, the demand for power is such as to require the steam to be admitted to the cylinder during one half to two thirds of the stroke. Besides, the habitual use of high-pressed steam in the cylinder reduces the relative importance of the atmosphere as a neutralizer of power.

Secondly, even were the power sufficiently great to permit of highly expansive working, the cylinders are in many engines so imperfectly protected, as partially to condense the steam within them. Moreover the proportion of steam condensed increases with the degree of expansion, and so serious is the destruction of power from this cause, that even were the pressure sufficiently great to permit of highly expansive working, the benefit of expansion, if it be attempted by cutting-off earlier than from one half to one third

of the stroke, is neutralized by the greater condensation of the steam thereby incurred.

The object of this paper is to show at what rate in practice the efficiency of steam is increased by expansive working in Locomotives with the best existing arrangements of cylinders, valves, and valve gear, and to point out the conditions on which expansive action may be most successfully carried out.

I.—*Of the action and capabilities of the Link-motion.*—The action of the valves in the "distribution" of the steam (a term borrowed from the French) is regulated by three elements, the lap, the lead, and the travel. When these are given, the point of the stroke of the piston at which the steam is admitted to the cylinder, cut-off, exhausted, and compressed or shut up, are all deduceable by model, by diagram, or by calculation. This can be done, whether the valve derives its motion from a single eccentric, or from a link-motion, as the motion of the valve is virtually the same in both cases. The way in which the valve is caused to cut-off or suppress the steam earlier by the link motion, is by *shortening the travel of the valve;* this is accomplished by means of the reversing gear, in such a manner that whatever be the reduction of travel communicated to the valve, the lead is always at least the same as in full gear, and with the shifting link is rather increased. In shortening the travel, not only is the steam cut-off at an earlier point of the stroke; it is also exhausted earlier, and admitted earlier, and the exhaust port is closed earlier during the return stroke upon the exhaust steam. Thus, by shortening the travel, every thing affecting the distribution is done earlier in the course of the steam and return strokes. This conclusion is very well illustrated by the excellent diagrams of the valve motion of the Atlas Goods Engine, with which the members of the Institution are familiar.

In his experiments on the action of steam, the writer employed Mc Naught's Indicator, which he applied to the front end of one of the cylinders of the engine, and received the alternate motion for the paper-cylinder from the end of the piston rod, through an intermediate lever suspended from the engine frame. To test the actual state of the valve-gear of each engine at the time of the

experiment, so far as it affected the distribution, Indicator diagrams were obtained from the cylinder at very low speeds, under each notch of the sector of the reversing gear. The diagrams so obtained, of which some examples are given in Figs. 1, 2, and 3, Plates 55 and 56, are angular and sharply defined, and they show with precision at what points of the stroke the changes of the distribution take place. For instance, in the diagram, Fig. 1, Plate 55, (from the Caledonian Railway Engine, No. 18, fitted with shifting links, taken under full-gear, in the first notch of the sector, and marked No. 1); the opening of the port for the admission of steam commences at the point A, about $\frac{3}{16}$ths-inch before the beginning of the steam stroke, when the line starts upwards to the regular steam level at B, in time to commence the steam stroke at full pressure. From B to C, the steam is shown to be admitted to the cylinder at a uniform pressure of 88 lbs. At C, it is cut-off, or suppressed, and while the piston moves from C to D, the enclosed steam expands behind it at a regularly decreasing pressure, shown by the curve C D. At D, the steam is exhausted, and the pressure quickly declines till the end of the steam stroke E. During the return or exhaust stroke, the steam continues to exhaust into the atmosphere, and the atmospheric line E F is described. When the piston arrives at F, the exhaust steam is denied any further egress, and the piston continuing in motion, it compresses the steam against the end of the cylinder, and raises the pressure as indicated by the line F A, until at A steam is admitted from the steam-chest for the next steam stroke. The *portions* of the double stroke described by the piston during this succession of changes or events, traced for one face of the piston, are distinguished by the writer as the *periods* of the distribution, and the *points* of the stroke at which the changes occur, as the *points* of the distribution. These are further distinguished as follow:—

A is the *point of admission;*

C is the *point of cutting-off, or suppression*;

D is the *point of exhaust, or release*;

F is the *point of compression;* also the portion of the stroke described while the line AB is traced, is the *period of pre-admission;*

The portion of the stroke BC is the *period of admission;*

The portion between C and D is the *period of expansion;*

The portion between D and E is the *period of exhaust* during the steam stroke;

The portion EF is the *period of exhaust* during the return stroke:

The portion between F and A is strictly the *period of compression;* but the period of *pre-admission* is generally added to it, and thus the compression usually signifies the whole distance of the point F from the end of the return stroke.

These definitions apply to diagrams taken from every notch of the sector, as it will be seen from the diagrams Nos. 2, 3, 4, Fig. 1. from the same engine, that however varied in form, they have all the parts of the diagram No. 1, for full-gear.

The following Table, No. 1, contains the positions of the points of the distribution of No. 13, C.R. Engine, for every notch of the sector, measured from the beginning of the steam stroke.

TABLE No. 1.—*The Distribution for No. 13 C.R. Engine.*

Stroke	20	inches
Lead in full-gear	$\frac{5}{16}$	,,
Ditto in mid-gear	$\frac{9}{16}$	,,
Lap	$1\frac{1}{4}$	,,
Travel	$4\frac{1}{2}$	,,

No. of Notch.	Points of the Distribution.							
	Cutting-off.		Exhaust.		Compression.		Admission.	
	Inches of Stroke.	Pr. cent. of Stroke.	Inches of Stroke.	Pr. cent. of Stroke.	Inches of Stroke.	Pr. cent. of Stroke.	Inches of Stroke.	Pr. cent. of Stroke.
No. 1, full-gear forward . .	$12\frac{1}{2}$	63	$17\frac{1}{4}$	86	$2\frac{5}{8}$	13	$\frac{3}{16}$	1
No. 2 . . .	$9\frac{3}{4}$	49	$16\frac{1}{4}$	82	$3\frac{3}{4}$	19	$\frac{5}{16}$	2
No. 3 . . .	$6\frac{5}{8}$	33	$14\frac{1}{4}$	72	$6\frac{1}{4}$	32	1	5
No. 4, mid-gear forward . .	$3\frac{1}{8}$	155	$10\frac{3}{4}$	54	$9\frac{5}{8}$	48	$2\frac{1}{8}$	11

1st.—It is obvious from this table, in conjunction with the diagrams, that the sooner the steam is cut-off, the sooner it is exhausted, the sooner the port is closed for exhaustion, and the sooner the port is opened for the admission of steam.

2nd.—That though every change is made earlier—as measured in parts of the stroke—there is less difference in the position of the points of exhaust, compression, and admission, than in that of the cutting off. Consequently, the shorter the admission, the longer is the expansion, as the exhaust point does not recede so much as the point of cutting off.

3rd.—That by the shifting link-motion, the steam may be cut off at from $\frac{1}{6}$th to $\frac{1}{7}$th of the stroke.

4th.—That though the exhaust takes place earlier for every increase of expansion, it does not in any case take place within the first half of the stroke. For mid-gear it occurs in fact at 54 per cent. of the stroke; and the steam is expanded into $3\frac{1}{2}$ times the length of stroke at which it is cut off.

5th.—That the period of compression, increasing as the admission is reduced, amounts to about one-half stroke in mid-gear.

6th.—That the pre-admission of the steam, not above 1 per cent. of the stroke in full gear, reaches about 10 per cent. in mid-gear.

These results are for an ordinary *shifting link-motion*, in every modification of which the lead increases with the degree of expansion, and in which the lead in this case rises from $\frac{5}{16}$ths to $\frac{9}{16}$ths inch in mid-gear. Whereas, in *stationary link-motions*, having the links suspended directly from a fixed point, the lead is constant for all degrees of expansion; and if in these the lead be set at $\frac{1}{4}$th to $\frac{5}{16}$ths inch constant, we should be able to cut off at even 10 to 12 per cent. of the stroke, or at $\frac{1}{10}$th to $\frac{1}{8}$th of the stroke. For example, in the diagram from No. 125, C.R. Engine, in Fig. 3, Plate 56, (lap $1\frac{1}{4}$ inch, lead $\frac{1}{4}$ inch,) the steam is shown in No. 5 diagram to be cut-off at $3\frac{1}{2}$ out of 24 inches stroke, or at $\frac{1}{7}$th from the front end of the cylinder. Now in this engine, as the valve-gearing was slightly out of balance, the steam was cut-off 1 inch earlier for the back stroke in mid-gear, that is, at $2\frac{1}{2}$ inches; and the mean of the two, or 3 inches, is the mean admission in mid-gear, or $\frac{1}{8}$th of the stroke.

It has been thought necessary to go into these preliminary explanations, to show that *the link-motion is capable of cutting off steam as early* in the course of the stroke *as can ever be advisable* in practice.

It has been seen that the earlier the steam is cut-off, the *earlier also it is exhausted*; until in mid-gear it may be released at half-stroke. This has been deemed a serious objection to the use of link-motions for high expansion, as it is supposed to lead to a serious loss of expansive action, by exhausting prematurely. This loss is, however, a mere trifle in practice. The escape of the steam is by no means instantaneous, as the slow diagrams in Figs. 1, 2, and 3, very clearly prove. Thus, in the diagram No. 1, Fig. 1, from No. 13, C.R. Engine, the exhaust-line DE shows that nearly all the period of exhaust for the steam stroke is employed for the complete evacuation of the steam. And if this be the case for speeds of 1 and 2 miles an hour, it is much more so for the regular working speeds of trains. To select from a very admirable series of Indicator diagrams, with copies of which the writer has been favoured by Mr. Daniel Gooch, by whom they were taken from the cylinder of the Great Britain Locomotive, on the Great Western Railway, the Figs 4 and 5, Plate 57, contain diagrams taken at 17 and 55 miles per hour respectively, under the 1st, 3rd, and 5th notches of the sector. The following are the conditions of the valve-motion of this engine, when the diagrams were taken:—

TABLE No. 2.—*State of the Valves of the "Great Britain," G.W.R.*

Cylinder, 18 × 24 inches. Wheel, 8 feet.

Lap . . . . $1\frac{1}{4}$ inch.
Constant lead . . . . $\frac{3}{8}$ „
Travel in full-gear . . . . . . $4\frac{3}{4}$ „
Blast orifice . . . . $5\frac{1}{8}$ „ diameter.

	Position of Points of Distribution.			Period of Exhaust during the Steam-Stroke
	Cutting-off.	Exhaust.	Compression.	
No. of Notch.	Inches of Stroke.	Inches of Stroke.	Inches of Stroke.	Inches of Stroke.
1	16	$21\frac{3}{8}$	3	$2\frac{5}{8}$
3	$11\frac{3}{4}$	$19\frac{3}{4}$	5	$4\frac{1}{4}$
5	7	$17\frac{3}{8}$	$7\frac{1}{2}$	$6\frac{5}{8}$

On the diagrams the points of cutting-off and exhaust are marked, and the steam-line falls only very gradually during the period of exhaust, especially at the high speeds. The expansion-curves are shown by dotted lines A, B, C, Figs. 4 and 5, continued to the end of the stroke. These are easily calculated in terms of the relative volumes of steam, from the pressures indicated at the points of exhaust, and are such as would have been described had the exhaust been delayed till the end of the stroke. The shaded areas A, B, C, enclosed between these dotted curves, and the curves actually described, express the *power lost* by exhausting the steam *before the stroke is completed.* Averaging them for the whole stroke, they are as follows:—

Low Speeds	1st Notch,	$\frac{7}{8}$ lb.	per	inch	loss.
	3rd ,,	$2\frac{1}{4}$,,		,,	,,
	5th ,,	$3\frac{1}{8}$,,		,,	,,
High Speeds	1st ,,	1 ,,		,,	,,
	3rd ,,	1 ,,		,,	,,
	5th ,,	$\frac{3}{8}$,,		,,	,,

The losses at high speeds are very small,—merely nominal; and curiously enough, the loss by the *earlier* exhaust of the 5th notch is actually less than that under the 1st notch. The losses are of course greater at the low speeds; but even then, in the 1st notch, which is the only notch employed at very low speeds, the loss does not amount to 1 lb. per inch. The 3rd and 5th notches are employed only at speeds much above 17 miles per hour, and the loss by them is of no practical moment.

Upon the whole, it follows that the possible *loss by the early exhaust* yielded by the link-motion is of *no importance.* On the contrary, it can be proved to be *beneficial,* as an early exhaust is at high speeds essential to a perfect exhaust during the return-stroke. It plainly appears, therefore, that with the existing arrangements of locomotives, any attempts to eke out the power on the steam-line, by prolonging the expansion materially beyond what is accomplished

by an ordinary valve and link-motion, are not only useless, but highly prejudicial.

Another objection to the link-motion is that the steam is injuriously *wiredrawn* by it when under great expansion. Hence the numerous attempts to supersede the link by the employment of a separate expansion-valve. The diagrams, Fig. 5, Plate 57, may be referred to as examples of wire-drawing by the link. They were taken nearly consecutively with one opening of the regulator; and it is clear that the steam attained fully as high a pressure in the cylinder under the 5th notch as under the 1st. The pressure falls considerably towards the point of cutting off, but from the form of the steam-line, it is plain that very little additional steam is admitted for an inch or two before the cutting-off actually takes place. The most of the steam is admitted at the higher pressure, and in fact a partial expansion of the steam already admitted takes place for some distance before the expansion nominally begins. Thus the *wire-drawing* is, to a great extent, equivalent to an *earlier cutting-off*, and a greater degree of expansion. The whole possible loss by wire-drawing is comprised within the dotted line D, added to the diagram, which is merely an extension of the expansion curve, to meet the steam line, drawn horizontally to represent a free admission up to an imaginary point D of cutting-off, 5 inches from the beginning of the stroke. This shaded area D amounts exactly to a mean loss upon the whole stroke of *one pound per square inch*, by *wire-drawing*, under high expansion. For the 1st and 3rd notch, the amount of loss by wire-drawing, must obviously be still less; and, in short, the objection of *wire-drawing by the link-motion*, when of liberal proportions, is of *no practical weight*.

Another objection to the link-motion, and apparently the most formidable one, is the large fraction of power neutralised by the *compression* of the exhaust-steam, and which increases with the degree of expansion. Compression, however, involves no loss of efficiency; for as by compression a quantity of steam is incidentally reserved and raised to a higher pressure, it gives out the power so expended

in compressing it, during the next steam-stroke, just as a compressed spring would do in the recoil. But, apart from this general argument, the actual efficiency of the steam in the cylinder, with and without compression, may be exactly estimated. The most direct method of doing so, is to find the quantities of water consumed as steam for one stroke, under the two conditions, and to compare them with the relative effective mean pressures. It will suffice to analyse, as an example, the high-speed diagram, Fig. 5, Plate 57, under the 5th notch, No. 5. The volume of steam admitted is measured by the product of the area of piston, (254·47 inches), and the period of admission, plus the total clearance in the cylinder and steam-passage; the clearance being measured for simplicity in inches of stroke, we have $7 + 1{\cdot}8 = 8{\cdot}8$ inches, for the total volume admitted. The pressure of the steam when cut-off is 65 lbs., for which the relative volume of water is 359. Therefore the volume of water as steam, or the water-equivalent of the steam admitted, is

$$\frac{254{\cdot}47 \times 8{\cdot}8}{359} = 6{\cdot}24 \text{ cubic inches.}$$

From this is to be deducted the quantity of steam reserved by compression; the volume so reserved is measured by the period of compression, plus the clearance ($7{\cdot}5 + 1{\cdot}8 = 9{\cdot}3$), and the pressure at the point of compression is 8 lbs., for which the relative volume is 1125. Then the water equivalent of the reserved steam is—

$$\frac{254{\cdot}47 \times 9{\cdot}3}{1125} = 2{\cdot}10 \text{ cubic inches;}$$

subtracting, there remains $6{\cdot}24 - 2{\cdot}10 = 4{\cdot}14$ cubic inches of water as steam, actually expended for one stroke of the piston.

Were there to be no reservation of exhaust steam by foreclosing the exhaust-port, the whole area of resistance by compression would be removed, and there would be a reserve of steam of atmospheric pressure equal in volume to the clearance only. The relative volume of atmospheric steam is 1669, and the water-equivalent of the reserve, would be—

$$\frac{254{\cdot}47 \times 1{\cdot}8}{1669} = 0{\cdot}27 \text{ cubic inches:}$$

the expenditure per stroke would be $6{\cdot}24 - 0{\cdot}27 = 5{\cdot}97$ inches of water.

Now, the positive mean pressure during the steam-stroke, as indicated, is	40·9lbs. per inch,
And the mean resistance by compression is . .	11·5lbs. „
Thus the effective mean pressure is	29·4lbs. „

This effective mean pressure of 29·4lbs. is maintained by a consumption of 4·14 inches of water per stroke; and it has just been found that with the compression removed, the positive mean pressure of 40·9lbs. per inch would be maintained by a consumption of 5·97 inches of water per stroke. The effective pressure created per cubic inch of water is, therefore,

In actual practice . . . . $\frac{29 \cdot 4}{4 \cdot 14} = 7 \cdot 1$lbs.

And would be by removing compression $\frac{40 \cdot 9}{5 \cdot 97} = 6 \cdot 9$lbs.

These quantities are expressions of the relative efficiency of steam employed with and without compression: they are virtually identical, and show that the resistance by compression in the cylinder, due to the action of the link-motion, does not in the slightest degree impair the efficiency of the steam.

The last objection to the use of the link, requiring notice, is that at *high speeds* considerable *back exhaust pressure* is created. The amount of this is very various, and it depends also on circumstances for which the link-motion is not responsible; such as a deficiency of inside lead, (which is regulated by the lap,) small ports, a small blast-orifice, and imperfect protection of the cylinder. It suffices on the present occasion to point to what can be done by superior arrangements, as exemplified in the diagrams, Fig. 5, Plate 57, from the "Great Britain." The cylinders of this engine are in a manner suspended in the smoke-box, and thoroughly protected; the steam-ways are very large, 13 × 2 inches, being in area about $\frac{1}{10}$th of the cylinder; the exhaust-passage is very direct; and the blast-orifice is $5\frac{1}{4}$ inches diameter, or about $\frac{1}{11}$th of the area of cylinder. As a whole, these proportions are superior to those of any other engines with which the writer is acquainted;

and the diagrams prove that the per-centages of back exhaust-pressure, in terms of the positive mean pressure, at 55 miles per hour, are—

For the 1st notch	. . . . . .	8⅝ per cent.
„ 3rd ditto	. . . . . .	5¼ „
„ 5th ditto	. . . . . .	nothing.

Better results than these should not in practice be required, for when locomotives are adapted to their work, and running at high speeds, they ought not to require an admission of steam above half-stroke. However, the area of blast-orifice rules the back exhaust-pressure; and, when the cylinder is duly proportioned to the boiler, it is quite practicable, by a few modifications in detail, still further to increase the orifice, sufficiently to banish all traces of back-pressure of exhaust at all practicable speeds.

Having noticed the prevailing *objections to the link* as a means of *variable expansive working*, and shown that there is no good ground for entertaining these objections, it remains to be shown at what rate the efficiency of steam is increased by expansive working.

II.—*Of the rate of Efficiency of Steam worked expansively in the Locomotive, by the Link-motion.*—It is customary to apply the law of expansion discovered by Boyle, and better known as Marriotte's law, to determine the work done by steam acting expansively. In the present case, this mode of inquiry would be of little service, for though steam in well-protected cylinders expands nearly according to Boyle's law, or such that the total volume by expansion varies inversely as the total pressure, yet the results are affected by other circumstances;—chiefly, the amount of clearance, wire-drawing, and back-pressure of exhaust and compression. It will be preferable to take the aggregate results of all these influences, as embodied in the model-diagrams from the "Great Britain:"—this method will ensure accurate conclusions, and will simplify the discussion. Twenty-six indicator-diagrams were obtained, at speeds varying from 15 to 56 miles per hour, of which the samples, Figs. 4 and 5, Plate 57, taken at the opposite extremes of speed, suffice to point out the general characteristics. The Table, No. 3, contains in the first nine columns an analysis of these diagrams, which requires no further explanation; the effective horse-powers, column 10, are

TABLE No. 3.—*Results from Indicator-Diagrams,*

No. of Diagram.	Speed of Engine in Miles per Hour.	Indicated Steam Pressures in Cylinder, in lbs. per Square Inch. Maximum Pressure during Admission	Positive Mean Pressure.	Back Pressures. Exhaust.	Compression.	Sum of Back Pressures. Pressure.	Per Cent. of positive Steam Pressure.	Effective Mean Pressure.
	Miles.	lbs.	lbs.	lbs.	lbs.	lbs.	Per Cent.	lbs.
1	15	70	63·8	1·6	2·4	4·0	6·1	59·8
2	17	88	80·0	0·6	1·9	2·5	3·0	77·5
3	21	95	86·2	1·2	3·0	4·2	4·7	82·0
4	24	85	76·7	0·9	1·6	2·5	3·1	74·2
5	27	80	70·6	1·5	2·2	3·7	5·3	66·9
6	31	90	79.6	1·7	3·7	5·4	6·7	74·2
7	31	80	73·2	2·9	2·2	5·1	6·9	68·1
8	49	60	51·4	3·6	4.4	8·0	15·5	43·4
9	54	89	80·4	6·8	6·0	12·8	15·8	67·6
1st Notch—Means		82						68·2
10	17	88	69·9	0·0	3·8	3·8	5·4	66·1
11	18	70	55·3	0·8	4·5	5·3	9·4	50·0
12	21	92	72·3	0·0	4·2	4·2	5·7	68·1
13	26	72	57·1	0·0	4·9	4·9	8.5	52·2
14	31	79	60·3	1·2	6·0	7·2	11·9	53·1
15	32	86	64·4	0·8	4·9	5·7	8·4	58·7
16	40	76	55·7	0·4	4·7	5·1	9·1	50 6
17	51	70	49·1	2·0	6·2	8·2	16.6	40 9
18	55	84	62·0	3·6	7·6	11·2	18·0	50·8
3rd Notch—Means		80						54·5
19	17	89	53·2	0·0	9·6	9·6	18·0	43·5
20	18	70	42·1	0·5	6·6	7·1	16·7	35·0
21	21	93	56·5	0·0	6·3	6·3	11·1	50·2
22	28	74	41·8	0·4	6·2	6·6	15·7	35·2
23	31	83	46·5	0·0	7·4	7·4	15·5	39·1
24	36	80	39·0	0·0	8.5	8·5	21·1	30·5
25	50	77	34·7	0·5	8 0	8·5	24·4	26·2
26	56	90	40·9	0·0	11·5	11·5	28·1	29·4
5th Notch—Means		82						36·1

taken from the "Great Britain" in 1850.

Effective Horse Power Indicated.	Water Equivalents. Total admitted for One Stroke, measured from Diagram.	Reserved by Compression.	Actually expended during one steam Stroke.	Actually expended per Hour.	Actually expended per Effective Horse Power per Hour.		Coke consumed per Effective Horse Power per Hour, allowing 1 lb. for 8 lbs. water.
H. P.	Cubic ins.	Cubic ins.	Cubic ins.	Cubic feet	Cubic ins.	lbs.	lbs.
190	13·32	1·00	12·53	89·83	817	29·5	3·69
284	15·89	0·82	15·07	124·53	758	27·4	3·42
372	16·71	1·09	15·62	159·45	741	26·8	3·35
384	15·30	0·82	14·48	168·95	760	27·5	3·44
389	13·89	0·91	12·98	170·37	757	27·4	3·42
497	15·62	1·13	14·49	218·35	759	27·4	3·42
456	14·76	1·00	13·76	207·35	786	28·4	3·55
459	10·73	1·34	9·39	223·60	842	30·4	3·80
763	15·62	1·56	14·06	369·07	836	30·2	3·77
						28·3	3·54
242	12·19	1·10	11·09	91·65	654	23·7	2·96
194	10·33	1·35	8·98	78·57	700	25·3	3·16
309	12·50	1·16	11·34	115·78	647	23·4	2·92
293	10·55	1·41	9·14	115·52	681	24·6	3·07
356	10·87	1·48	9·39	141·50	687	24·8	3·10
407	11·33	1·29	10·04	156·20	663	24·0	3·00
437	9·78	1·35	8·43	163·87	648	23·4	2 92
450	8·65	1·54	7·11	176·30	677	24·5	3·06
603	10·54	1·66	8·88	237·42	680	24·6	3·07
						24·3	3·03
159	7·90	1·85	6·05	50·00	543	19·6	2·45
136	6·59	1·76	4·83	42·26	537	19 4	2·42
228	8·20	1·42	6·78	69·21	525	18·9	2·36
213	6·87	1·68	5·19	70·64	537	20·7	2·59
262	7·29	1·59	5·70	85·89	566	20·5	2·56
237	6·08	1·85	4·23	74·02	540	19·5	2·44
263	5·52	1·76	3·76	91·39	600	21·7	2·71
353	6·24	2·10	4·14	113·20	554	20·1	2·51
						20·1	2·51

estimated in terms of the diameter and stroke of cylinder, the diameter of wheel, and the effective mean-pressures in the 9th column. The water-equivalents, columns 11, 12, and 13, are estimated from the indicated pressures and the period of the distribution for each notch, in the way already exemplified. The expenditure of steam per hour, column 14, is deduced from column 13, in terms of the speed, the cylinder, and the wheel; and, dividing that by the effective horse-power, we have the contents of column 15 in inches, and of column 16 in pounds. Column 17 contains the coke consumed per horse-power per hour, deduced for the several diagrams from the consumption of water, column 16, allowing 1lb. of coke to evaporate 8lbs. of water.

Referring to the contents of the last two columns of this table, it is obvious that the consumption of water as steam, or of coke, for a given amount of work done, becomes less the more expansively the steam is worked; and the means of the several quantities for the notches separately are as follow:—

CONSUMPTION PER HORSE-POWER PER HOUR.

For the	1st notch,	28·3 lbs.	water,	or	3·54 lbs.	coke.
,,	3rd	,,	24·3 ,,	,,	,,	3·03 ,,	,,
,,	5th	,,	20·1 ,,	,,	,,	2·51 ,,	,,

As the results under each notch vary very little, the means above stated may be adopted for all practical speeds without material error. To find from these means a formula which shall express the rate of economy by expansive working: it may be done graphically thus:—see Fig. 6, Plate 56. Draw a base-line AB, to represent the stroke of the piston; set off on this base-line the distances AE, AF, and AG, equal respectively to the periods of admission under the 1st, 3rd, and 5th notches. From the points E, F, G, draw the perpendiculars equal respectively to the pounds of water per horse-power per hour consumed under the different notches, by any convenient scale of pressure, and terminate them by points, as drawn; these points are found to range in a straight line, CD, which meets the vertical from A, at a height of 14 lbs. by the scale, and the vertical from B, at 36 lbs. The straightness of the line

CD implies that the consumption decreases uniformly with the period of admission of the steam; the difference of heights, (36—14) or 22 lbs., is the whole decrease for the whole stroke. Consequently, if 22 be multiplied by the period of admission, and divided by the length of stroke, and 14 added to the quotient, the sum will express the consumption.

Let L = the length of stroke,
S = the period of admission of steam,
and W = the consumption of water in pounds per horse-power per hour;

$$\text{then } W = 22\frac{S}{L} + 14 \quad \text{- - - - - - - - - - -} \quad (1.)$$

or, at length:—

RULE I.—*To find the Consumption of Water as Steam per Horse-power per hour, for a given period of admission.* Multiply the period of admission in inches by 22, and divide by the length of stroke in inches; and add 14 to the quotient. The sum is the required consumption in pounds.

For the *Consumption of Coke*, allowing 1 lb. for the evaporation of 8 lbs. of water, divide the water, as above found, by 8; and, making C the consumption of coke, we have

$$C = 2{\cdot}75\frac{S}{L} + 1{\cdot}75 \quad \text{- - - - - - - - - - -} \quad (2.)$$

or, at length:—

RULE II.—*To find the Consumption of Coke per Horse-power per hour, for a given period of admission.* Multiply the period of admission in inches by 2·75, and divide by the length of stroke in inches, and add 1·75 to the quotient. The sum is the consumption in pounds per horse-power per hour.

These rules may be employed with safety for all periods of admission between 10 and 75 per cent. of the stroke, which are the utmost limits worth regarding in the locomotive engine. They are applicable, also, for maximum pressures during admission, ranging between 60 lbs. and 120 lbs., though based on results from steam of 80 lbs. to 84 lbs. maximum pressure. For extreme pressures, the results by the rule are slightly too small in the case of lower pressures, and rather greater for the higher,—these divergences being

due to the constant deduction of 15 lbs. for atmospheric resistance from the total pressure. It is presumed that engineers will not return to the error of low pressures in locomotives, and that high pressures will be cultivated. For pressures above 80 lbs., the rules are perfectly safe, as they err rather by excess on the safe side. The relative advantage of higher pressures, in respect of the constant loss by the atmosphere, progresses but slowly for pressures above 80 lbs. At this pressure, or 95 lbs. total, the atmosphere deducts $\frac{1}{6\cdot33}$rd; and at 100lbs., the loss is $\frac{1}{7\cdot66}$th. The difference of these fractions is $\frac{1}{36}$th, which is all the economy on account of atmospheric resistance by the use of 100 lbs. steam, compared with the work done at 80 lbs. For 120 lbs., the economy is $\frac{1}{21}$th, and for 150 lbs, it is $\frac{1}{15}$th, with respect to 80 lbs. The chief advantage, therefore, of the highest pressure, is in the liberty of working more expansively, while developing power at a given rate.

The following Table, No. 4, shows in the second column the consumption of steam worked expansively per horse-power per hour, due, by Rule I, to the periods of admission named in the 1st column, and expressed in per cent. of the stroke. The inverse ratios of those quantities of steam are entered in col. 3, the consumption for 100 per cent. being expressed by 1. Thus the actual relative efficiency of steam is found for various admissions. The 4th column contains the theoretical maximum relative efficiency of steam, expanding to the end of the stroke, according to the law of Boyle, with a perfect vacuum behind the piston, and without clearance, back-pressure, or compression; extracted from the ordinary tables on the subject. In col. 5, are given the relative amounts of work done by steam, under the admissions named in col. 1, being directly as the effective mean pressures in the cylinder, which are found by a rule to be afterwards given.

TABLE No. 4.—*Efficiency of Steam by Expansion in the Cylinder of the Locomotive, in Actual Practice.*

For Maximum Pressures during admission of 60 lbs. to 120 lbs.

Periods of Admission in Parts of Stroke.	Water as Steam consumed in Pounds per H. P. per Hour.	Relative Efficiency of Steam in Actual Practice.	Possible Maximum Efficiency.	Relative Work done by Steam of the same Maximum Pressure in the Cylinder.
Per Cent.	lbs.			
10	16·2	2·22	3·30	15
12·5	16·7	2·15	3·08	20
15	17·3	2·08	2·90	24
17·5	17·8	2·02	2·73	28
20	18·4	1·96	2·60	32
25	19·5	1·85	2·39	40
30	20·6	1·75	2·20	46
35	21·7	1·66	2·05	52
40	22·8	1·58	1·92	57
45	23·9	1·50	1·80	62
50	25·0	1·44	1·69	67
55	26·1	1·38	1·60	72
60	27·2	1·32	1·51	77
65	28·3	1·27	1·43	81
70	29·4	1·23	1·35	85
75	30·5	1·18	1·28	89
100	36·0	1·00	1·00	100

From this table it appears that, in actual practice, the relative efficiency of steam when cut-off at $\frac{1}{10}$th of the stroke, is $2\frac{1}{4}$ times greater than when not cut-off until the end of the stroke, but that theoretically the increase should be $3\frac{1}{4}$ times instead of only $2\frac{1}{4}$;—therefore the actual efficiency of steam increases with expansive working, at a much slower rate than would be possible if every drawback were extinguished. Atmospheric resistance cannot as

yet be removed; but a material advantage would result from a reduction of the clearance between the valve and the piston.

As 75 per cent. is the greatest admission materially required under the link-motion, the relative efficiency for that admission (1·18), being compared with the efficiency (2·22) for 10 per cent. of admission, they are as 1 to 1·9, or nearly 1 to 2; and it follows that under the most favourable existing circumstances, *the utmost possible efficiency of steam worked expansively* in locomotive engines by the link-motion *is about twice* that of the steam when worked under *full gear*; that is, the *same quantity of steam* does *twice the quantity* of work.

The effective mean pressure is to some extent affected by the speed; but to find the average rate of increase with the admission, take the means of the maximum and of the effective mean pressures in Table No. 3, cols. 3 and 9, as follows :—

No. of Notch.	Average Maximum Pressure in Cylinder.	Average Effective Mean Pressure in Cylinder.	
		Pressure.	Per Cent. of Average Maximum Pressure.
	lbs.	lbs.	Per Cent.
1	82	68·2	83
3	80	54·5	68
5	82	36·1	44

The per-centages in the last column may be arranged in a curve, see (Fig. 7, Plate 55,) having the base line AB to represent the stroke, and the perpendiculars at E, F, G, equal to the respective per-centages measured on a vertical scale. The curve must pass through the point A, as, when no steam is admitted, no work can be done; the other end at D must also terminate somewhere *below* 100 by the scale, as even with an entire admission something must come off for back pressure. From the curve, the following formula is derived for finding the per-centage of effective mean pressure due to a given admission, in terms of the maximum pressure :—

Let A = the per-centage of Admission, and P = the per-centage of Effective Mean Pressure, then

$$P = 13{\cdot}5 \sqrt{A} - 28 \quad - \; - \; - \; - \; - \; - \; - \; - \; - \; - \quad (3).$$

RULE 3.—*To find the Effective Mean Pressure in the Cylinder, in terms of the maximum pressure, for a given per-centage of admission.* Multiply the square root of the per-centage of admission, by 13·5, and subtract 28 from the product; the remainder is the Effective Mean Pressure in per-centage of the maximum pressure of steam admitted.

The results by this rule are rather too small for lower speeds, and rather too great for higher; but the deviations are of no practical moment. At 40 miles per hour, or 560 feet of piston per minute for the "Great Britain," the result exactly coincides with practice; and this is an ordinary speed of piston in both Goods and Passenger Engines, as, though the usual speed of the former on the rails is less than that of the latter, the wheel is smaller, and the stroke is commonly longer. The rule applies very well to admissions between 10 and 75 per cent., and to pressures (maximum) from 60lbs. to 100lbs., or even 150lbs.

The following Table, No. 5, of Effective Mean Pressures, is calculated by means of the foregoing rule, for admissions advancing by twentieths of the stroke, or intervals of 5 per cent.; and, fortunately, most of them may be accurately expressed in common fractions, as in the last columns of the table.

In all well-protected cylinders, with blast-orifices, not less than $\frac{1}{16}$th of the area of the cylinder, the foregoing rules and tables of data apply to the action of steam at speeds under 30 to 40 miles an hour. For speeds amounting to 55 to 60 miles an hour, the loss by imperfect exhaust causes a large increase of consumption per horse-power per hour, of from 33 to 12 per cent., according to the amount of admission. With steam-ports of about $\frac{1}{14}$th, and blast-orifices $\frac{1}{14}$th of the cylinder, the rules likewise apply, at speeds under 30 to 40 miles an hour. At the higher speeds, the useful power is considerably impaired by imperfect exhaust.

TABLE No. 5.—*Effective Mean Pressure in the Cylinder, for various Admissions.*

For Maximum Pressures of 60 lbs. to 150 lbs.

Periods of Admission in parts of the Stroke.	Effective Mean Pressures, in parts of Maximum Pressure.	Periods of Admission in common fractions of Stroke.	Effective Mean Pressure, in common fractions of the Maximum Pressure.
Per Cent.	Per Cent.		
10	15	1-10th	1-7th full.
12·5	20	—	—
15	24	1-8th	1-5th
17·5	28	—	—
20	32	1-6th	1-4th
25	40	1-5th	1-3rd
30	46	1-4th	1-2·5th
35	52	1-3rd	1-2nd
40	57	—	—
45	62	—	—
50	67	1-2nd	2-3rds
55	72	—	—
60	77	—	—
65	81	2-3rds	4-5ths
70	85	—	—
75	89	3-4ths	9-10ths

The proportions of the "Great Britain" may be applied to any other engine, and they may be repeated here as standard ratios for practice, until superior results are obtained.

Sectional area of cylinder 1
„ steam-port 1-10th
„ blast-orifice 1-11th
Lap of valve, 1¼ inch.

Travel, $4\frac{3}{4}$ inch, in full-gear.
Lead, $\frac{1}{4}$ to $\frac{3}{8}$ inch.

So wide a blast-orifice as $\frac{1}{11}$th, is a rare thing in Locomotives; but the writer is satisfied that even in engines of very unfavourable proportions otherwise, a very wide orifice may be obtained by the proper adjustment of matters of detail.

In a second part of this paper, the writer proposes to discuss the *conditions* necessary for the successful expansion working of steam in Locomotives.

The following is a comparison of the actual results of Engines working with ordinary *Gab-motions*, and with *Link-motions.*

The engine "Europe," on the Edinburgh and Glasgow Railway, cylinder 16 × 18 inches, wheel 6 feet. Doing one week's work, in 1849, with *gab-motion*, consumed an average of 19 cwt. of coke per day, and 2 cwt. of coal. As, in the locomotive boiler, coal is about two-thirds of the value of coke, 2 cwt. of coal is equivalent to 1.33 cwt. coke; and the consumption per day may be stated at 20.33 cwt. coke.

The same engine, fitted with *link-motion*, used at the same season in 1851, and doing the same work, 12 cwt. of coke, and 3 cwt. of coal daily, equivalent to 14 cwt. coke: over a run of 94 miles, the expenditure becomes

24·22	lbs. per mile	with	gab-motion
16·70	,,	,,	link-motion
7·50	lbs. reduction, or 30 per cent. with link.		

The periods of admission in the two cases would be about 70 and 45 per cent, and by the Table of Efficiency, the consumption would be as 1·50 to 1·23, showing an economy of only 18 per cent., or barely two-thirds of what was actually made. The greater actual efficiency must in great part be due to the superior opportunity of working with high pressure, during the admissions afforded by the link.

Again, the test may be applied by measuring the water consumed. The following are a selection of cases from the writer's own experience and observation.

Engine with Link-motion, cylinder 15 × 20 ins., wheel 6 feet.
Edinburgh and Glasgow Railway.

		Mean Speed. Miles Per Hour.	Average Train of Carriages.	Consumption of Water in feet, pr. Mile.	
1851. 26 Aug.	"Orion," ordinary train.	19·6	16	2·97	Stiff Wind ahead.
" "	Do. do.	24·4	7	2·01	Do. favourable.
27 "	Do. do.	24·4	7	2·22	Do. ahead.
" "	Do. Express	32·0	5	1·65	Do. favourable.
1850. 7 Sep.	Do. do.	32·7	5	1·65	Slight wind ahead.

Engines with fixed Gab-motion, cylinder 16 × 18 ins., wheel 6 feet.
Edinburgh and Glasgow Railway.

1850. 3 Sep.	"America," ordinary	21·5	13	3·01	Wind favourable.
10 Oct.	"Nile," Expr.	29·0	7½	3·00	Do. ahead.
21 "	"Niger," "	—	7	2·80	Calm.

Express Engine, with fixed Gab-motion, cylinder 16 × 18 ins., wheel 6 feet. North British Railway.

1851.	Express	38·5	5	2·70	Calm
	"	38·5	5	2·70	Do.
	"	38·5	4	2·96	Wind ahead
	Mail	35·7	7	3·05	Calm
	Ordinary	22·0	12	3·45	Calm

These results show, as before, that under similar circumstances, what has been deduced from an independent examination of Indicator-diagrams, taken under the Link-motion, as to the *economy* of steam *worked expansively*, is fully borne out by a direct appeal to the relative consumption of coke and water.

The CHAIRMAN observed that he felt much obliged to the author of the paper for explaining in such a clear and practical manner the action of the slide-valve and the link-motion; and the paper was particularly valuable for the actual numerical results that were given so completely of the variations in practical working, showing the improvements effected and the defects avoided.

Mr. McCONNELL considered the practical investigation of the subject given in the paper was very valuable. He agreed that the link-motion was the most advantageous and useful of any valve-motions known for Locomotive engines; and the mode of hanging the link from a fixed centre, adopted by Mr. Gooch in the Great Western engines, had the advantage of preventing the increase of lead that took place in the ordinary link-motion when working with much expansion. He considered that the surcharging of the steam in the smoke-box was a valuable suggestion, and might very probably admit of being carried out so as to effect an important economy. And he thought that a hot-air chamber should be contrived, passing round the cylinder, and kept constantly in such a temperature as to prevent any condensation of steam during expansion, and ensure the steam being always maintained perfectly dry, without any water being ever present in the cylinder from condensation or priming. The suspending the cylinders in the smoke-box was a good plan in the Great Western engines, but a special arrangement was required for the purpose of thoroughly carrying out the principle in a proper manner.

Mr. CLARK said that in the engines referred to, Mr. Gooch had carried the steam pipe straight down in front of the tubes, instead of curving it on one side as usual, and the pipe being made of one-eighth inch copper, the heat from the tubes was rapidly communicated through it, and the steam became much heated. In the experiments with the Great Britain engine, it

had been found that there was considerably less difference between the pressure of the steam in the boiler and that in the cylinder, than was the case in other engines where the steam did not get so much heated; and Mr. Gooch had found in repeated experiments, very carefully tried, that the pressure was actually a little higher in the steam chest than in the boiler, the difference being greater at a higher speed, and amounting to as much as 7 to 10 lbs. per inch in some cases, the pressure in the cylinder being equal to that in the boiler, and in some cases 2 or 3 lbs. above, instead of being considerably below, as was the case in most engines in regular work. He could only suppose that the elastic force of the steam was increased by its becoming surcharged with heat in the smoke-box after leaving the boiler, but could not account for a greater pressure being apparently maintained in the steam chest, whilst the steam was flowing into it from the boiler.

Mr. Slate could not see how a greater pressure could exist in the steam chest than in the boiler, as the steam would in that case flow back to the boiler till the pressure was equalised.

The Chairman observed, that with regard to the question of surcharging steam, he remembered being told by Mr. Trevithick of an experiment which he made in Cornwall in 1830. He had to repair an old engine there, which had no steam jacket to the cylinder, as most of the other engines had, to keep up the pressure of the steam; and he built a brick casing round the cylinder, leaving an air space all round, and applied a small fire to keep this air heated. About one bushel of coals in twenty-four hours was consumed in heating the cylinder, and he found a great increase was effected in the duty performed by the engine, with the same consumption of fuel under the boiler as before. He then removed the fire from the cylinder, in order to find the relative efficiency of the coal when consumed under the boiler or under the cylinder, and he found that it took five bushels of coals applied to the boiler to produce the same effect as the one bushel of coals applied to the cylinder.

The Chairman said, he had been so much impressed with the results of this experiment, that in the Planet, one of the early locomotives made in 1832, he had the cylinders carefully enclosed inside the smoke box instead of being outside, and there was found to be a considerable increase of power effected by the plan. That was the first locomotive constructed with heated cylinders, and it appeared the principle ought never to have been deserted; but it was singular how temporary prejudices sometimes caused a good thing to be departed from. Those inside cylinders were abandoned because the crank axles were found liable to break, but then after that objection was subsequently removed by improved manufacture, the prejudice against the inside cylinders still remained; however, they appeared now to be going back to them. The construction of locomotives was still perhaps much influenced by these local prejudices arising from individual circumstances; and he was confident that this Institution would conduce greatly to the removal of them, by the mutual interchange of ideas and experience that was promoted by it; and nothing could assist more in forwarding such a desirable object than the reading of such papers as the present one by Mr. Clark.

He quite agreed with the opinion stated in the paper on the great drawback to the application of expansion in locomotive engines caused by the condensation, from the cylinders not being heated; he considered some additional heat was required to be supplied during expansion to prevent condensation taking place, as it appeared the quantity of heat in steam was not sufficient to maintain the whole in the form of steam during expansion, but a portion returned to the form of water, as shown in the able investigation of the expansion of steam given in Lardner's Treatise on Heat.

Mr. Cowper described some experiments that had been made by Mr. Siemens and himself, which he thought showed that condensation did not take place during expansion. They took a cylindrical tin vessel closed at the top, about twelve

inches high and two inches diameter, the metal of which was very thin, and coated thickly with felt outside to prevent any loss of heat. A small steam pipe was connected at the top, but the bottom of the cylinder was open to the atmosphere; and a stream of 30 lbs. steam was blown into the vessel from a very small orifice, and allowed to escape freely into the atmosphere at the open end of the cylinder. After a short time, when the cylinder had become hot, and was maintained just full with expanded steam at the atmospheric pressure, a thermometer inserted a short distance into the open end, showed a constant temperature of 214° to 215° instead of 212°, proving the total quantity of extra heat that is in high pressure steam; and no condensation could be perceived inside the cylinder, no vapour being visible until the steam had escaped from the cylinder into the atmosphere. This experiment was tried on several different occasions, and on one it happened that the boiler was priming slightly; and when a drop of water came over through the steam pipe and dropped upon the bulb of the thermometer, it was observed to fall suddenly to 212°, and remained at that point until the water was boiled off, when it again rose 2° to 3° above the boiling point as before. The experiment had been suggested by Mr. Siemens, and was a very ingenious one.

The Chairman said, he did not think that mode of trying the experiment would give a correct result as regarded the present question, as the steam was escaping into the atmosphere instead of being all confined within the cylinder, and the temperature in the cylinder being maintained above the boiling point would prevent any condensation taking place during the expansion of the steam.

Mr. Cowper did not think that in a cylinder that was thoroughly protected from loss of heat by radiation or conduction, any condensation of the steam would take place during expansion, and that if any condensation occurred, it would be found to be owing to the steam having lost some of its heat, which it could not recover. The result that he obtained by

indicator diagrams from a pair of 35 horse-power, high-pressure, expansive, and condensing engines, which he had constructed some years since, fully bore out this view; the steam was expanded in the cylinder of each engine independently, and the practical expansion curve was obtained very accurately. The whole body of the cylinder was necessarily nearly at a mean temperature between the highest and lowest steam in the cylinder, (the cylinder not having a steam jacket,) consequently the steam ought to be slightly cooled on entering the cylinder, and towards the end of the stroke, where it was at a lower temperature from expansion, it ought to be slightly warmed by the cylinder;—now the indicator figure showed both these circumstances to have taken place, for the actual curve during the first part of the stroke, after the steam had been cut-off, was rather below the true expansion curve, and during the latter part of the stroke it was rather above; this also showed that the expansion curve required a slight correction for the extra quantity of heat in the high-pressure steam.

Mr. Clark remarked that he had found by the indicator diagrams, that a great condensation of the steam took place in exposed outside cylinders during the first part of the stroke, from the coldness of the cylinders, and a considerable amount of condensation also was caused even in protected cylinders, where they were not artificially heated by exposure to the hot air in the smoke-box, because the temperature of the mass of metal in the cylinder remained about the mean temperature of the steam whilst expanding in the cylinder, which might be many degrees below the original temperature of the steam on entering from the boiler. This caused the actual pressure of the expanding steam to be below the theoretical pressure during the first half of the stroke, as shown in the indicator diagram, Fig. 3, Plate 56; where the theoretical curve of expansion is shown by the dotted line BCD, allowing for the contents of the steam port and the clearance represented by the space AA. But about the middle of the stroke, the two curves

coincide at C, as the steam was then at its mean temperature, and agreed with the temperature of the cylinder; and after that point, as the steam continued to expand and lower in temperature, the cylinder remaining nearly constant was hotter than the steam, and returned some of the heat it had robbed from the steam, re-evaporating more and more of the water that had been condensed, and raising the curve of actual pressure above the theoretical curve at the end D, where the exhaust commences. A portion of the lost steam is thus restored in the second half of the stroke, but a serious loss of power still remains; and the consideration of this action that is always going on to a greater or less extent in the cylinders of Locomotives, however well they may be protected, except where they are artificially heated, shows what an important source of economy is to be found in carrying out that principle.

The CHAIRMAN proposed a vote of thanks to Mr. Clark for his valuable and interesting paper, which was passed.

The following paper by Mr. J. E. McConnell, of Wolverton, was then read :—

ON A NEW PORTABLE LIFTING MACHINE.

The object of this machine, which is the invention of Mr. Long, Royal Hydrometer Maker, London, is to obtain, in a portable and simple form, the means of multiplying the power of a man to a very great extent, for the purpose of lifting weights, &c., without the drawback of heavy friction and wear to which some lifting machines are liable, such as those in which an endless screw works into a toothed wheel. A specimen of this machine is before the meeting, and the construction is shown in Figs. 1 and 2, Plate 58.

A is a wheel, on which eleven pins, BH, are fixed in the form of teeth, with a friction roller fitted upon each pin.

The circular plate CC is fixed at right angles to this wheel, upon the shaft of the winch D, to which the manual power is applied. On this plate is cast the spiral projecting piece EFG, which makes rather more than one turn upon the plate. This spiral is engaged with the pins BH on the first wheel, and the difference in the amount of eccentricity of the two ends of the spiral is equal to the pitch or distance between the pins; so that when the plate C and spiral are turned round one revolution by the handle, the wheel A is driven round the distance of one pin or tooth.

The driving face of the spiral has a varying bevil, adjusted so as to bear fairly and uniformly upon each pin in succession throughout the entire revolution, as the pin varies its inclination from B to H; the next pin above, I, being then brought down into the position B.

The thickness of the spiral, as shown at G, nearly fills the space between the two pins at all times, preventing any slip, and the upper pin is engaged a short distance before the lower one is released.

The friction roller upon the pin turns round during the motion, rolling, with little friction, along the inner surface of the spiral, which forms an inclined plane, with an inclination of about 1 in 7.

A pinion fixed on the wheel A is geared into one of three times the diameter on the third shaft, K, upon which is fixed the drum L, for winding up the rope or chain attached to the weight to be lifted. The leverage of the spiral and first wheel being 11 to 1, and that of the spur gearing 3 to 11, makes a power of 33 to 1, and the radius of the winch handle and of the drum being 6 to 1, the total increase of power obtained by the machine is 200 to 1 very nearly; or one man exerting a power of ½ cwt. at the winch could lift five tons, including the friction.

This machine has the advantage of reducing the friction, in consequence of the rubbing action being confined to the revolving of the friction rollers upon their axles, instead of the inclined plane rubbing upon the pins, or the thread of an endless screw rubbing upon the teeth of a worm wheel, which has only contact at little more than a line. This has a scraping action, tending constantly

to remove the oil from the surface, but in the friction rollers there is a much larger surface in contact to bear the pressure, and this surface being always in contact never has the oil scraped off the surface, and can retain the oil for a much longer time.

The same principle of a spiral is applied in a convenient and efficient manner in the vice shown in Figs. 3 and 4, in which the projecting spiral acts upon the teeth of a straight rack, connected to the sliding jaw of a parallel vice.

Another application is also shown in Fig. 5, to a rack-pulley for a window-blind cord, in which the pulley can be conveniently tightened or slackened or removed as required, and is held in its place by the spiral.

Mr. McConnell exhibited one of the lifting machines at work, and specimens of the vice and rack-pulley. He said he had only lately become acquainted with the invention, and it appeared to him worth bringing under the notice of the meeting; there might be some other practical applications that would be useful on account of the reduction of friction in transmitting the power. The vice was a convenient form, as the jaws were always parallel, and the lever was out of the way of the man.

The thanks of the meeting were given to Mr. McConnell for his communication.

The consideration of Mr. Lamb's Marine-Engine Boiler was postponed in consequence of the absence of the author.

The Chairman announced that the next Meeting of the Institution would be an additional meeting in London, in June, for which some valuable papers were in preparation; and he congratulated the members on the prosperous position of the Institution, and its increasing efficiency and usefulness.

The Meeting then terminated, and the members adjourned to the library, where coffee was served, and several interesting objects were exhibited.

M. Bourdon, from Paris, exhibited several varieties of his Manometer or pressure-gauge for steam boilers and other purposes, with a series of models, illustrating the principle on which the instrument is constructed; namely, a flattened metallic tube, bent into a circular curve, and acted upon in the interior by the pressure of the steam, &c., causing the curvature to diminish and the detached end of the tube to move in proportion to the degree of pressure, and indicate the pressure by moving the index on the dial, the tube being elastic. These instruments were stated to be found very correct in practice, not liable to derangement or inaccuracy, and convenient in application as steam-pressure gauges, vacuum gauges for condensers, or pressure gauges for gas, &c.; and were adopted for general use by the government inspectors of steam-boilers in France. A portable barometer was exhibited, constructed on the same principle and similar in form to the aneroid barometer. Also an ingenious instrument for measuring velocity of rotation, founded on a property of the peculiar form of curved tube that was employed in the above instruments, to increase its internal capacity in proportion to the diminution of its curvature; this instrument was proposed to be brought before the Institution in a more complete form.

Mr. Follett Osler, of Birmingham, exhibited to the members an extensive series of diagrams, taken from his new compound self-registering Anemometer, fixed at the Liverpool Observatory. This instrument is a further improvement on the former self-registering Anemometer constructed by Mr. Osler, and erected at the Birmingham Philosophical Institution in 1840; described in the Transactions of the British Association. In this instrument, in addition to the constant record of the *direction* and *force* of the wind, by two lines traced by the instru-

ment itself, upon a continuously moving sheet of paper, the *velocity* is recorded by a third line, and the *quantity* by a fourth line. The *direction* and *force* are recorded by two pencils upon one flat sheet of paper, which is changed every day, and is fixed on a table moved at a uniform rate by a clock, and having the successive hours, &c., marked upon it. The *direction* pencil is moved in a straight line across the paper by means of a quick-threaded screw geared to the wind vane, tracing on the paper a waving longitudinal line, the paper being ruled longitudinally by fixed pencils to mark the cardinal points; the wind-vane is similar to the fan-wheel at the back of a windmill. The *pressure* pencil is moved transversely upon the paper by connection through wires with the pressure-plate, a circular disc four square feet area, which is held always at right angles to the direction of the wind, to receive the full pressure upon springs at the back, which yield according to the degree of pressure; a fixed pencil rules the datum line upon the paper.

The *velocity* and *quantity* are recorded on a continuous sheet of paper which is moved by the wind itself, at a rate exactly proportionate to the velocity of the wind; the successive hours being marked upon the paper whilst passing, by means of a punch which is in connection with the clock, and strikes a blow on the arrival of each hour. The distances between these successive hour-marks on the paper, give consequently by a scale the measure of the *velocity* of the wind at each time; and the total length of the paper that is passed in an hour or a day gives the measure of the total *quantity* of air that has passed the place during the time, one inch of the paper representing thirty-eight miles of air. The length of one sheet of paper was thirty-one feet, for the month of January last, representing that the total quantity of 14,000 miles of air had travelled past the place during the time; that quantity being the sum of all the currents of air in all directions at that particular place. The motion of this paper is obtained from a vertical spindle which has four horizontal arms, three feet long, fixed on the top at right

angles to each other, each carrying at the extremity a hemispherical cup, eight inches in diameter, fixed vertically, so that when one presents its hollow side to the wind, the opposite one presents its convex side in the same direction. The moving power of the wind upon the convex side is only one-half as great as its power on the hollow side, and consequently the whole instrument is caused to revolve; but as the hollow side moves with the wind, and the other against it, the result is that the instrument revolves at the rate of one-third the velocity of the current of air. (This plan, having been originally discovered by Mr. Edgeworth, was first applied to Anemometers by Dr. Robinson). For the purpose of ascertaining the variations in the velocity of the current, when an unusually large quantity of air is passing, as in the case of a storm, there is an additional marking apparatus which can be thrown into gear with the clock, and strike a mark on the paper at every minute, or five minutes, or quarter of an hour, as desired, during the continuance of the storm, and be then discontinued when the velocity of the paper is sufficiently diminished. This instrument is the first that has been constructed of this compound kind, and it has continued in constant work for about half a year with entire success; it has stood without any injury or derangement the trial of a very severe storm on 9th January last, when the pressure of the wind reached to 29 lbs. per square foot, as recorded on one of the sheets exhibited, and the greatest velocity was 62 miles per hour.

Mr. Edwin Cotterill exhibited his improved Bank Lock, and a number of specimens of different ingenious applications of the principle of his lock. The large Bank Lock, which received great attention and commendation from the members, is shown in Plate 59. It consists of a series of 24 radiating steel slides AA, shown in the section Fig. 3, and in the elevation Fig. 5, (which has the front plate removed, as well as the centre piece, shown separately on a larger scale in Figs. 1

and 2.) The slides AA move in radiating channels in the main barrel of the lock BB, and each slide is pressed to the centre pin by a separate spiral spring C C. A circular groove D D, is cut in the face of the barrel and of the slides, (when the slides are forced outwards to their right positions by the insertion of the key,) so that a continuous circular channel is formed by the coincidence of the different portions of the groove in the face of the barrel and the notches so cut in the several slides. Into this circular channel enters the notched ring E, (shown separately in Fig. 4,) which is fixed to the top frame of the lock FF, and remains stationary, whilst the barrel B, with the set of slides and springs, revolves with the key. But when the key is withdrawn, each of the slides is forced in different degrees towards the centre by its spiral spring, sliding also through the several notches in the fixed ring E, so that their solid portions intercept the groove in the barrel, (as shown in Fig. 5), and in this position the barrel is held fast by the fixed ring E, and the lock is prevented from turning. The key, shown in Fig. 7, consists of a cylindrical stem, having a series of radiating grooves cut in its circumference, corresponding to the slides in the lock; these grooves are inclined in the bottom, and they all vary in depth, length, and the angle formed by their bottom with the axis of the key. When placed in the lock for the purpose of opening it, the key is pressed down to the bottom, and each slide entering one of the grooves of the key, they are forced outwards by the inclined bottom of the grooves, to the various distances according to the depth and form of the grooves; and when the key is pressed home the notches in all the slides exactly coincide with the circular groove in the barrel, leaving a clear passage for the notched ring E, and the barrel, with all the slides, is then turned round with the key by means of the projecting bits on the key. Should an attempt be made to open the lock with a false key, one or more of the slides would be pushed too far, or not far enough, and then it would intercept the circular groove D, and prevent the barrel from turning, by locking it fast with

the fixed ring E. The revolution of the barrel B, causes all the bolts of the lock to be thrown, by the toothed ring G, fixed upon the outside of the barrel, working into the wheel H, on the axis of which is the pinion I, that turns the wheel K, and this throws the bolt L, by means of the pins forming a rack upon the end of the bolt. The other bolts MM, (16 in all), are thrown by similar wheels NN, which are all driven simultaneously with the wheel K, by means of the toothed ring O, which revolves loose on the barrel B, and gears into each of these wheels.

The centre piece, shown separately on a larger scale in Figs. 1 and 2, (elevations taken from the inner side) contains the "nosle-drop," P, which is a steel plate, closing the keyhole Q, and prevents the key from entering the lock, until it is removed into the position shown in Fig. 2, by the key making one revolution previously, and turning round the inner cylinder R, which moves the drop on one side by the pin on the cylinder at R, and the key is then ready to enter the lock, the key-hole being again instantly closed by the drop when the key is removed, by the spring pressing it over the pin, which slips under the drop in that position. But the cylinder R, has a notch S, which is locked by the vertical slide T, (shown unlocked in Fig. 2, and altogether removed in Fig. 1); and it cannot be made to revolve until this slide T, is withdrawn by means of the safety key or "sentinel" shown in Fig. 6, which turns round the barrel U, (Fig. 2), and draws down the slide T, by the projecting bit on the barrel acting on the notch in the tumbler V, which is centred at the top upon the slide T. This tumbler is pressed up by a spring, Y, and has an L-shaped slot, in which a fixed pin works, and this pin holds down the tumbler and slide, when pressed into the horizontal part of the slot by the action of the bit on the revolving barrel, U. This holds down the slide T, and prevents it from again catching the cylinder R, until the main key is put into the lock; but directly the main key begins to turn, the rocking lever W, which had before rested on a flat

place in the cylinder R, is thrown out by coming in contact with the circumference of the cylinder, and the lower end of the lever W, presses in the tumbler V, and releases it from the pin by bringing it into the vertical portion of the slot in the tumbler, which is then pressed up by the spring Y; and the slide T, is pressed against the cylinder R, ready to lock into the notch S, directly it comes opposite. The "sentinel" key, (Fig. 6,) is a complete counterpart of the main key on a smaller scale, and acts on a complete lock on the same principle, with six radiating slides, and having the key-hole closed by a "nosle-drop" X, in the same manner. Consequently, before the main lock can be opened, the sentinel key has to be turned once round to open its own key-hole, and then pressed home to move the slides in its lock to the right position, for enabling the key to turn a second time and unlock the catch from the main key-hole; the main key is then put in, and by the first revolution in the same manner opens its key-hole and is then pressed home, and by a second turn the lock is opened. This operation, though apparently complicated, is in reality as simple as unlocking two successive doors of the bank safe, both having been double-locked; but by this plan extreme security is obtained, as a lock of great security has first to be picked before the key-hole of the main lock can be opened, and any steps taken towards picking it.

A further security is obtained by means of a detector slide, which is attached to one or more of the slides in the lock, so that if any one of those slides is pressed out too far by a false key or otherwise, although the slide were brought back to its right place, the detector slide would remain projecting into the circular groove, forming an effectual obstruction to the revolution of the barrel; and this obstruction could not be removed even by the right key in the ordinary manner, thereby detecting the attempt upon the lock, until the key was first turned backwards for a certain distance, which draws back the detector slide into its place, and restores the lock to its ordinary state. The keys

are cut by a machine for the purpose, which admits of being varied whilst working, to such an extent, that the key of every lock is made different, two only being cut alike as duplicates for each lock; the key is made first in each case, and the lock is formed to the key, by the slides being fitted to the key, the circular groove in the barrel and slides being cut simultaneously whilst the key is in its place; the form of the grooves of the key gives it the peculiar advantage that an impression cannot be taken from it, and the difficulty of making a correct duplicate of the key is so extreme, (except by the original cutting machine whilst adjusted to cut each groove of the first key), as to prevent risk of the key being copied. The slides being firmly guided in the grooves of the barrel, and the key-hole securely closed by the nosle-drop, protects the lock effectually from injury by violence from gunpowder or otherwise.

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INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

SPECIAL GENERAL MEETING,

HELD IN LONDON, ON 29TH JUNE, 1852.

J. E. McCONNELL, ESQ., VICE-PRESIDENT,

IN THE CHAIR.

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PROCEEDINGS.

THE SPECIAL GENERAL MEETING of the Members was held at the Rooms of the Society of Arts, John Street, Adelphi, London, on Tuesday, 29th June, 1852. The Chair was taken by J. E. McCONNELL, Esq., Vice-President, in the unavoidable absence of the President, Robert Stephenson, Esq., M.P.

The SECRETARY read the Minutes of the last General Meeting, which were confirmed.

The following Paper by Mr. ANDREW J. ROBERTSON, of London, was then read:—*

ON THE MATHEMATICAL PRINCIPLES INVOLVED IN THE CENTRIFUGAL PUMP.

Centrifugal Pumps, the principles of which form the subject of the following paper, will no doubt be remembered as occupying a conspicuous position in the Great Exhibition of last year. The first impression on seeing these pumps, was naturally surprise, that so simple a machine, and occupying but little space, should be capable of throwing so great a volume of water.

Simplicity is, no doubt, a very great merit in itself, and when it can be obtained, without the sacrifice of other things of more importance, is extremely desirable; moreover, this characteristic of the pump in question gives it a peculiar advantage in practice, which will be more particularly alluded to hereafter; but before a correct judgment can be formed of its merits as a whole, it is evidently necessary to compare not only the proportion between the size and effect, but between the *power* required to be expended, and the *useful work* accomplished.

It is unnecessary for the present purpose to enter into any description of the details of these pumps. Their form may be varied according to circumstances; for instance, they may have one, two, or six

* The Secretary explained that this paper had been incorrectly announced as by Mr. Michael Scott of London, and was written by his assistant Mr. Robertson, to whom the credit and the responsibility of the paper were due.

arms. In discussing the general principle, it will be sufficient to take a form which, while it embodies the principle completely, will serve to set it in the clearest light.

The Pump may, then, be said to be composed of a horizontal arm or pipe A, in Fig. 1, Plate 60, and a vertical pipe B, dipping into a cistern C, from which the water is required to be raised; the whole is supported in such a manner that B constitutes an axis, about which the machine is made to revolve by means of a steam engine acting on the crank D. Suppose that the arm is filled with water, as shown in the figure, and that the arm is in motion; the water contained in the arm A has then a centrifugal force, the amount of which depends upon the angular velocity with which it is revolving. It is manifest that this velocity must be such as to produce a centrifugal force, equal to the weight of a column of water of the same section as the arm, and of a length equal to the height of the discharge pipe above the surface of the water in the cistern, in order that the column of water in the pipe B may be supported.

When this velocity increases, the centrifugal force is in excess, the water flows through the arm A, and is delivered into a conduit to take it off. The amount of this delivery depends therefore upon the excess of the angular velocity above that required to keep the arm full.

The question we have now to examine is, what is the power required to drive this Pump, and what is the useful effect, estimated by the product of the quantity delivered, by the height which it is raised.

Let a be the angular velocity of the arm.

R the length of the arm in feet, and consequently the radius of the circle described by the extremity.

G the distance in feet of the centre of gravity of the water contained in the arm, from the centre.

Let the area of the section be constant throughout its length, and equal to unity, and let w be the weight of the water contained in one foot of the arm.

$$\text{Then the whole weight } W = R\,w, \text{ and } G = \frac{R}{2}$$

$$\text{And the centrifugal force} = \frac{a^2}{g}\,W\,G^* = \frac{a^2\,R^2}{2g}\,w$$

* Moseley's "Mechanical Principles of Engineering and Architecture," Equation 108, p. 125.

Or, for the sake of simplicity—

$$\text{Let } w = 1, \text{ then the centrifugal force} = \frac{a^2 R^2}{2g}$$

Now a R is the actual velocity with which the outer end of the arm is moving, and $\frac{a^2 R^2}{2g}$ is the height due to that velocity.*

The centrifugal force of the water is therefore represented by the weight of a column of water of equal section with the arm, and of a height equal to that due to the velocity of the end of the arm. And, as was observed before, the part of this column which is effective in *producing a flow* through the arm is the *excess* of the height of this column above the height of the orifice of discharge, reckoned from the surface of the water in the cistern.

What, then, is the velocity of flow so produced?

In estimating the effect of the centrifugal force, the velocity required to be communicated to the water in the vertical pipe may be neglected for the present, because by increasing the area of its section relatively to that of the arm it may be reduced considerably, and for the sake of simplicity, it may be considered as nothing. This subject will be alluded to hereafter.

Let AB, in Fig. 2, Plate 60, be a pipe of equal section throughout.

Let the water in it be in motion. After a small period of time, the water which occupied the space AB will occupy the space CD. The portion CA drops off, and an equal quantity of water DB, at rest, is added.

The portion DB is put in motion suddenly, by virtue of its continuity with the water in AD, but in thus being put in motion it reacts upon the water in AD, and checks its velocity.

Now suppose that, instead of being added at rest, DB had a motion equal to that of the bulk of the water, no retardation would be produced; and conversely, if that water be moving through the arm with the velocity with which the portion DB can be constantly added, that velocity will be maintained uniform. But the velocity with which DB can be added is that due to the head of water acting on the arm, and therefore the velocity of flow is that due to the excess of the

* Moseley's "Mechanical Principles of Engineering and Architecture," Equation 38, p. 53.

column representing the centrifugal force above the length of the vertical-pipe.

If h be the length of the vertical pipe, then $\frac{a^2 R^2}{2g} - h$ is the effective head, and the velocity of flow is $\sqrt{2g\left\{\frac{a^2 R^2}{2g} - h\right\}} = \sqrt{a^2 R^2 - 2gh}$

Let the velocity of the water at the end of the arm be V, and that due to the length of vertical pipe $h = v$, then the velocity of flow $= \sqrt{V^2 - v^2}$ and since the area of the section of the arm is unity, the discharge per second is also represented by the same expression $\sqrt{V^2 - v^2}$

Next—to estimate the amount of power required to be expended upon the machine to produce this discharge.

Every particle of the water contained in the arm has the same circular motion as the part of the arm it is in.

The water, therefore, as it leaves the arm, has a velocity equal to that of the outer end, and its direction would be a tangent to the circle described by the end.

But it has also a velocity (that of the discharge) in the direction of the length of the arm, or the radius of the circle; its actual motion, therefore, in magnitude and direction, will be represented by the diagonal AE of the parallelogram ABED in Fig. 3, Plate 60, one side of which, AD, represents the first velocity above mentioned, and AB or DE the other.

What we are concerned about at present is the amount only of this velocity.

$$AE^2 = ED^2 + AD^2 = AB^2 + AD^2 = (V^2 - v^2) + V^2 = V^2 - v^2$$

The number of units of work accumulated in a body moving with a given velocity (which is the power required to be expended to produce that velocity) is represented by the formula—

$$U = \tfrac{1}{2}\, \frac{w}{g}\, v_1^2 \,*$$

where v_1 is the velocity, and w the weight.

In the present case $v_1^2 = 2\,V^2 - v^2$

$$w = \text{discharge per second} = \sqrt{V^2 - v^2}$$

$$\therefore\ U_1 = \frac{(2\,V^2 - v^2)\ \sqrt{V^2 - v^2}}{2g}$$

* Moseley's "Mechanical Principles," &c., Equation 44, page 69.

But not only is the water now in motion which was formerly at rest, but it is in motion at a *higher level.* The total number of units of work which must therefore have been done upon the machine, is the sum of the number of units expended in producing motion, and the number expended in raising the water to the height h or $\frac{v^2}{2g}$, which is represented by

$$U_2 = \frac{v^2}{2g} \sqrt{V^2 - v^2}$$

Therefore the *total power* expended is equal to

$$U_1 + U_2 = \frac{V^2}{g} \sqrt{V^2 - v^2}$$

or the *power* expended on the machine is measured by the quantity of water delivered, raised to *twice the height* due to the velocity of the circumference of the arm.

As to the *useful effect* produced, it is simply the water delivered raised to the height h, or $\frac{v^2}{2g} \sqrt{V^2 - v^2}$

Since a body in motion is, theoretically, always capable of raising itself to a height due to the velocity, it will be clear that the water when delivered with considerable velocity must be capable of doing work, either by impinging upon a machine to which it might communicate motion, or by raising itself to an additional height; and if the power thus inherent in the water could be taken advantage of without interfering with the discharge, the result would be that the useful effect would equal the power expended; supposing for argument's sake that friction and such causes of loss did not exist.

But there are great practical difficulties in the way of recovering power from water in motion. The useful effect of an undershot water-wheel is only 33 per cent., and then the water flows with a full body in a confined channel; but in the centrifugal pump it flies off from all parts of the circumference of a circle. Had the direction of the motion been that of the radius of the circle, a dish of the shape shown at E in Fig. 4, Plate 60, would have guided the water, and it might have been delivered into a trough at a higher level. Even then, the friction of the surface of this dish would greatly diminish the velocity, and consequently the power of rising; but, unfortunately, as has been shown,

the direction is that of the diagonal of the parallelogram AE, Fig. 3, from which it will be evident that the length of the path which must be described by the water before the trough in Fig. 4 could be reached must be very much greater than in the case supposed above.

We must therefore come to the conclusion, that unless some means can be devised of recovering the power of the motion of the water, it must be thrown away, and consequently lost—for it is only by misapplication or waste that power can correctly be said to be lost, action and reaction being always equal.

The amount of this loss or *waste of power* is then—

$$\frac{V^2\sqrt{V^2-v^2}}{g}-\frac{v^2}{2g}\sqrt{V^2-v^2}=\frac{2V^2-v^2}{2g}\sqrt{V^2-v^2}$$

The expression vanishes, or the loss is nothing, when $v = V$, or when the delivery is nothing, that is, when the velocity of the circumference is that due to the height h of the arm above the water.

Since the total power expended is $\frac{V^2}{g}\sqrt{V^2-v^2}$

And the useful effect is . . . . . . $\frac{v^2}{2g}\sqrt{V^2-v^2}$

The per-centage of *useful effect* is $100\frac{\frac{v^2}{2g}}{\frac{2V^2}{2g}}=\frac{v^2}{2V^2}\times 100$

or the height to which the water is raised divided by *twice the height* due to the velocity of the circumference of the arm.

Suppose, then, a Pump required to throw a certain quantity of water, the velocity through the arm may evidently be made very little if the section be large; and the limit to which this enlargement of the section may be carried is imposed only by practical convenience. In this case, v^2 is but little less than V^2, and may be taken as equal in the left-hand factor of the expression for the waste of power, which then becomes—

Waste of power . . . . $=\frac{1}{2}\frac{V^2}{g}\sqrt{V^2-v^2}$

Total power expended $=\frac{V^2}{g}\sqrt{V^2-v^2}$

or the *waste* is exactly *one-half the power* expended.

Thus we see that the *limit* to which an *approximation* may be made, but which can never be practically realised, is that the useful effect should be half the power, or 50 per cent.

In the foregoing investigation the horizontal arm has been considered for the sake of simplicity to be situated at the upper extremity of the vertical pipe; in practice it is usually more convenient to place it in an intermediate position, having part of the column above and part below; this however does not affect the principle of the investigation.

Hitherto, the power absorbed by the velocity required to be communicated to each particle of water as it leaves the cistern and rises in the pipe B, Fig. 1, has been neglected; nor is it necessary to assign a definite value to it. By enlarging the pipe B, it may be greatly reduced, but as it can never be removed entirely, it constitutes one item of that loss which has to be deducted from the theoretical limit of 50 per cent.

There is, again, the friction of water in passing through the pipe B, and the arm A; and, lastly, there is the friction of the machine itself.

In Whitelaw's Mill, when a head of water is employed as a source of power, and where the waste arising from the communication of a circular motion to the water contained in the arm is avoided, the causes of loss just mentioned are in most respects the same.

The writer believes that in this machine the per-centage of useful effect has been found to be from 70 to 75 per cent. In estimating the useful effect likely to be realised by the Centrifugal Pump, we may take this as a guide, and since in this case 50 per cent. is the limit instead of 100 per cent., we have $\frac{75}{100} \times 50 = 37\frac{1}{2}$ per cent. as the practical result.

Although, therefore, the waste of fuel in employing this Pump is very great, it does not follow that it cannot be employed with advantage under any circumstances. There are many cases when fuel is cheap, and when it is consequently of greater importance to effect a saving in the first cost of a machine, than in the quantity of fuel which it consumes. Local peculiarities, too, may render it not only difficult to erect a Pumping Engine of the ordinary construction, which requires strong and heavy foundations, but even impossible.

In alluvial formations of great depth, a firm foundation can be obtained only at great expense. In such cases, the simplicity, the lightness, the cheapness, and, it may be added, the portableness of such a machine as the Centrifugal Pump, are advantages which may greatly outweigh its want of economy in the consumption of fuel.

Mr. Buckle enquired whether indicator figures had been taken to ascertain, practically, the loss of power in work done by centrifugal pumps?

Mr. Stein (in the absence of Mr. Robertson, the author of the paper, who was prevented by illness from attending), explained that the paper was only intended to investigate the theory of centrifugal action, as applied to raising water, not the practical results of machines that had been constructed; the object was to show that the centrifugal action is not the one to be aimed at, being a losing action, as far as raising the water is concerned.

Mr. Buckle said he thought that in raising water it was best to lift the water by direct action, and there was a loss of power in giving it a circular motion.

Mr. Stein observed, that in centrifugal pumps there is not only the radial action from the centre to the circumference, but also that in the direction of the tangent; the former only is effective in raising the water, the latter being all lost, and only making the water revolve round a fixed centre, which absorbed so much of the power uselessly.

Mr. Buckle considered a balanced bucket-and-clack pump best for short lifts, and a plunger-pump with equilibrium clacks best for all high lifts. He asked what was the limit to the height to which water could be raised by centrifugal pumps?

Mr. Stein said there was, theoretically, no limit to the height, it only depended on the velocity given to the circumference of the arms.

Mr. Phipps thought that quite an erroneous view of the

question was taken in the paper. It supposed that the water issued from the arms with the full tangential velocity, which would involve a great loss, but that was not the case. He thought it might be put in a different way. Imagine that an elastic band round the periphery of the revolving arms confined the water, and represented the resistance to be overcome; this band would yield a little outwards, in proportion to the pressure, and give vent to an annulus of water at a slow speed, not at the great tangential velocity supposed, but at the rate corresponding to the difference between the internal and external pressure. He understood Mr. Appold's experiments with his centrifugal pump at the Exhibition gave an effect of 70 per cent. of the power expended.

Mr. Bishop could not see what became of the lost power, if so much of it was not effective as was argued in the paper.

Mr. Stein explained that the paper was only upon the principles of the true centrifugal pump; there were perhaps some rotary pumps which might involve another principle of lifting the water by an inclined-plane action of the oblique arms, which would not involve a loss of power to the same extent, but the investigation in the paper applied only to those pumps with radial arms, where centrifugal action alone was employed.

Mr. E. A. Cowper observed, that Appold's pump had curved or oblique arms, which would have an inclined-plane action to some extent in lifting the water.

Mr. H. Grissell said he had constructed two large pumps for draining purposes, on Appold's plan, which worked exceeding well, lifting 8,000 and 10,000 gallons of water per minute. Mr. Appold had made experiments on the power employed, and had found, he understood, a result of about 70 per cent., but did not know the exact means by which the power was measured.

Mr. Phipps said he believed Mr. Appold had tried an experiment on the power consumed, by means of a Prony's friction-break, upon a centrifugal pump at his factory.

Mr. EDWARDS, of Birmingham, said he had manufactured several of Gwynne's centrifugal pumps, and he had recently tried an experiment with one that contained some further improvements of his own invention, having a revolving disc 13 inches in diameter, and driven at 800 revolutions per minute; it raised 650 gallons of water per minute to a height of 17½ feet, with a five-horse power steam engine, which he considered was equal to a duty of 70 per cent.

Mr. CRAMPTON inquired whether the actual power had been measured that was developed by the engine, and employed in that experiment, by means of an Indicator or otherwise? He believed that an effect of 70 per cent. of the power employed had been found to be obtained in Appold's Pump at the Exhibition, but only about half that effect from Gwynne's Pump.

Mr. EDWARDS replied that the power had not been measured by an Indicator in his experiment, but had been calculated from the dimensions of the engine and the pressure of steam at the time, which he thought would be nearly correct. It was a high-pressure steam engine, with a cylinder 8-inch diameter and 18-inch stroke, working 100 double strokes per minute, and the steam was at 45 lbs. per inch; the back pressure, he thought, would not be more than about 2 lbs. per inch on the piston.

Mr. BUCKLE observed, that it was very deceiving to form any estimate of the power given out by a steam engine from the pressure of the steam in the boiler; and it was impossible to ascertain the effective moving pressure in the cylinder unless by taking indicator figures.

Mr. McCONNELL considered it was essential in such experiments to measure the power employed by means of indicator figures from the engine, or some kind of dynamometer, as no accurate practical results could be obtained otherwise; and he thought it was very desirable to obtain more correct data than appeared to be accessible at present, for a further discussion of so important a subject.

A vote of thanks was passed to Mr. Robertson for his Paper, and the discussion was adjourned to the next meeting.

The following Paper, by Mr. Daniel K. Clark, of Edinburgh, was then read, being the continuation of the Paper read by him at the last meeting:—

ON THE EXPANSIVE WORKING OF STEAM IN LOCOMOTIVE ENGINES.

In this paper it is proposed to consider the conditions on which the expansive working of steam in Locomotives may be most beneficially carried out.

The Condensation of Steam in the Cylinder by exposure, which takes place in certain arrangements of locomotives, is susceptible of proof in various ways: by the internal evidence of the indicator-diagram, in respect of its general form, the form and course of the expansion-line, and the back pressure; also, by a comparison of the volume of sensible steam which is found to pass through the cylinder, with the volume of water found by measurement to be consumed from the tender and the boiler. The evidence of the expansion-line of the indicator-diagram will be first considered, both for well-protected and partially-protected cylinders.

Of the Evidence of the Expansion-line of the Indicator-diagram.—By Regnault's experiments it is proved that the total heat of saturated steam increases slightly with the pressure, at such a rate that for atmospheric steam it is 1179° Fahr., and for 100 lbs. of steam it is 1217°, or 38° more. This difference is of little importance, except as it shows that when steam of higher pressure is expanded and falls to a lower pressure, it becomes slightly surcharged with heat as it expands, assuming that it does not part with any of its heat, and that there is *at least* no necessary condensation of steam during expansion, and that in fact there cannot be any, except what arises from the abstraction of the heat of the steam by external causes.

If water be present with the steam in the cylinder during expansion, as there commonly is, the heat of surcharge would convert a part of this water into steam. If 100 lbs. steam be expanded down to 20 or 30 lbs., the accession of steam in this way would be about $\frac{1}{40}$th of what is originally admitted; although the difference is so small, even for so prolonged an expansion, as not to require further consideration in the present inquiry.

The slow diagrams from No 13 Caledonian Railway Engine, Fig. 1, Plate 61, supply examples of the results of condensation, and its influence in modifying the expansion-line. If the steam which is cut off be permitted to expand in the cylinder without any abstraction of its own heat, there can be no alteration of the whole quantity or mass of steam, whatever the change of volume may be; and the quantity of steam virtually saturated, indicated at the end of the expansion, or at any intermediate stage, should be found the same as at the commencement. If it be either greater or less, some change by condensation or otherwise must have taken place in the condition of the expanding steam. Referring to the diagrams from No. 13, (for which the points of distribution of the steam have already been given in the first paper)—if the whole clearance at the end of the cylinder, including the port, measured by 1¼ inches of stroke, be added to the volumes of the steam at the beginning and end of the expansion, the sums so found will be measures of the total initial and final volumes of the steam expanded, and the ratios of these volumes for each notch are contained in the 2nd column of table No. 6, following. The observed initial and final sensible pressures are added in columns 3 and 4. Dividing, in each case, the total volume of the steam, (equal to the product of the area of the piston and the length of stroke representing the volume) by the relative volume due to the pressure, the quotient is the water-equivalent, or the volume of water at 60° from which the steam is formed. The initial and final water-equivalents for each notch are entered in cols. 5 and 6, and their differences in col. 7, distinguished as positive (+) if in excess of the initial quantity, and as negative (—) if in deficiency; the 8th col. contains the values of these differences as per-centages of the initial equivalents. In col. 9 are the pressures with which the expansion would have ter-

minated, had the initial quantity of steam in each case been preserved intact throughout the expansion; these pressures are found, in each case, by multiplying the relative volume of steam, of the initial pressure, by the ratio in col. 2, which gives the relative volume of the final body of steam, and consequently its pressure. Col. 10 contains the differences of the final pressures so calculated, and those actually observed, col. 4.

TABLE No. 6.—*Of the Expansion and Water-Equivalents of Steam in the Cylinder of No.* 13. *C. R.*

No. of Notch.	Ratio of Total Initial and Final Volumes.	Observed Pressures.		Water-Equivalents.				Final Pressure due to an equal Final Equivalent.	Difference of Final Pressures in Cols. 4 and 9.
		Initial	Final.	Initial	Final.	Difference of Initial and Final.			
	Ratio.	lbs.	lbs.	Cubic Ins.	Cubic Ins.	Cubic Ins.	Per Cent. of Initial.	lbs.	lbs.
1	1 to 1·34	38	22	4·73	4·56	—·17	—3½	23½	+1½
2	1 to 1·58	41	19	3·99	4·01	+·02	+ ½	19	0
3	1 to 1·95	38	16	2·74	3·26	+·52	+19	10½	—5½
4	1 to 2·66	39	13	1·58	2·29	+·71	+45	4	—9
1	2	3	4	5	6	7	8	9	10

By tracing expansion-curves on the diagrams of No. 13, with the final pressures in col. 9, and otherwise such as would have been described with *a constant quantity of saturated steam* under expansion, the deviations of the actual curves from these, as standards, are easily shown. For No. 1 diagram, Fig. 1, Plate 61, the new dotted curve CD lies for its whole length *above* the actual, and terminates at 1½ lbs. more. For No. 2, the curves nearly coincide; for No. 3, the new curve proceeds for some distance above the actual, then crosses and falls lower as it advances, until it ends at 5½ lbs. below the other; for No. 4, the new curve AB passes on as in No. 3, and ends at 9 lbs. below the actual. These deviations are all referable to one cause—*the condensation of the steam.*

In No. 1, the cylinder must have been at a lower temperature than the steam during the admission, and some condensation must have taken place, for no sooner is the steam cut off, than condensa-

tion is made visible by the sinking of the expansion-curve below the standard throughout the whole of its length. In No. 2, also, this takes place to a small extent for the first half of the curve, when the temperatures of the steam and the material of the cylinder become equal; after this, as the pressure continues to fall, and the temperature of the steam with it, the curve rises and meets the standard curve at the end, in virtue of a partial re-evaporation of the steam previously precipitated, caused by the cylinder itself, which, colder than the steam, and heated by it in the first stage of the expansion, is now relatively hotter, and partially restores the heat of which it had previously robbed the steam.

In Nos. 3 and 4, the process of successive condensation and re-evaporation is still more distinctly brought out. In these cases, the greater portion of the heat engaged in the restoration of the steam during expansion must have been absorbed by the cylinder, by condensation of the steam during admission. A reference to cols. 7 and 8 shows the magnitude of this condensing agency, for under the 3rd and 4th notches, the observed final equivalents are shown to exceed the initial by 19 and 45 per cent. of the latter respectively; which proves that, in the two cases, at least 19 and 45 per cent. of the steam admitted *must have been condensed during admission*, as the additional steam can have been obtained from no other source. Although the actual expansion-curves, Nos. 3 and 4, indicate much higher mean pressures, *during expansion*, than the standard curves, and may so far be viewed as superior results, the favourable difference is only a partial amends for the much greater loss by initial condensation; and an expansion-curve may be constructed backwards, in terms of the indicated mass of steam at the end of the expansion, to show from what initial pressure this mass of steam could have expanded, had there been no condensation. Take No. 4, for example. The final pressure at E is 13 lbs., for which the relative volume is 939, and the ratio of the initial and final total volumes, or the degree of expansion, is 1 to 2·66; then $939 \div 2{\cdot}66 = 353$, which is the relative volume for 66¼ lbs. steam at the point of suppression. Tracing the expansion-curve EF for this pressure, as in the drawing, for which any number of intermediate points may be found in the same way, and drawing a horizontal ad-

mission-line FG to the beginning of the stroke, the extra shaded area so enclosed is a representation of the real loss incurred by initial condensation of steam: and, without going into figures, it appears nearly as much again as the area, or power, actually obtained.

The diagrams just discussed, are, of course, extreme cases, which might occur in any cylinder, outside or inside; and they have been selected simply for purposes of illustration. They have served to show in what way the expansion-curves of indicator diagrams may be turned to account in developing the condition of the steam. Our business is now to find to what extent, in the ordinary working of locomotives, the condition of the steam is affected by the circumstances of the cylinder.

It so happens, though not necessarily so, that inside cylinders are in general better protected than outside cylinders. The former are more completely within the smoke-box, and are more closely in contact with the smoke, and derive more benefit from its heat, than the latter; though, of course, there are many examples of inside cylinders being, for mechanical reasons, completely excluded from the smoke-box, and having no other advantage over outsides than that they are less exposed to atmospheric draughts. The distinction of outside and inside, occasionally employed in this paper, must be understood to refer, not to constructive arrangements, but to the incidental conditions of exposure and protection.

The stress of the argument will be derived chiefly from the results obtained from the well-protected cylinders of the "Great Britain," Great Western Railway, on the one hand, and the partially-protected cylinders of the Caledonian Railway passenger and goods engines, on the other, of which the passenger class, derived originally from the Crewe pattern, represent a widely-ramified species of outside-cylinder locomotive. Fig. 5, Plate 60, shows cross sections of the cylinders and smoke-boxes of the three classes of engines now referred to, in which it is apparent that the inside cylinder is the best protected.

The first point is to show, by the expansion-line, that in well-protected cylinders the steam is not subject to condensation. Referring to the twenty-six indicator-diagrams from the "Great

Britain," of which specimens were given in the last paper, the following table, No. 7, contains, in col. 1, the initial and final volumes of the steam expanded, clearance included, measured in inches of the stroke; in cols. 3 and 4, the observed initial and final pressures; in cols. 5 and 6, the initial and final water-equivalents of the expanded steam, deduced in terms of the capacity of the cylinder, and the relative volumes of steam due to the pressures; col. 7 contains the differences of these equivalents. At the foot of the table are added the means for each notch.

It appears that for each notch the influence of speed on the relation of the initial and final water-equivalents of the steam expanded is nearly inappreciable. Dealing, therefore, with the means, it appears that the mean differences, col. 7, constitute,—

For the 1st notch, 3 per cent. of the initial equivalent.
„ 3rd „ 5½ „ „ „
„ 5th „ 2¼ „ „ „

These per-centages are practically nothing, and the virtual constancy of the mass of expanding steam during expansion, thereby proved, shows that for the greatest observed degrees of expansion in the cylinder of the "Great Britain," no change in the condition of the steam is observable, and that there is, consequently, no condensation at all.

Experiments made by the writer on some of the engines of the Edinburgh and Glasgow Railway, with inside cylinders, lead to the same conclusion.

Of the numerous diagrams obtained from the outside-cylinder engines of the Caledonian Railway, seventy-six were selected by the writer as average samples of diagrams obtained by him during the regular work of the engines. These have been analysed in the way adopted for those of the "Great Britain," and the mean results for each engine are tabulated below, ranging from 9 per cent. deficiency, to as much as 67 per cent. excess at the greatest expansion. Specimens of the diagrams from No. 42, Passenger-engine, and from No 125, Goods-engine, are given in Fig. 2, Plate 61. These diagrams were taken by McNaught's indicator, and the dotted lines show the actual curves which are affected by the oscillation, to which that indicator is subject at high velocities. The mean

TABLE No. 7.—*Of the Expansion and Water-Equivalents of Steam in the Cylinder of the "Great Britain."*

Initial and Final Volumes by Expansion, in Inches of the Stroke, clearance included.	No. of Diagram.	Observed Pressures during Expansion.		Equivalents of Water.		
		Initial.	Final.	Initial.	Final.	Difference.
		lbs.	lbs.	Cub. Ins.	Cub. Ins.	Cub. Ins.
	1	70	50	13·32	13·37	+0·05
FIRST NOTCH.	2	88	65	15·89	16·16	+0·27
	3	94	65	16·71	16·16	—0·55
Cutting off 17·8 Ins.	4	84	57	15·30	14·65	—0·65
	5	74	49	13·89	13·19	—0·70
Exhaust . . 22·8 ,,	6	86	55	15·62	14·29	—1·33
Expansion 1 to 1·3	7	80	56	14·76	14·47	—0·29
	8	52	34	10·73	10·32	—0·41
	9	86	60	15·62	15·23	—0·39
	10	87	43	12·19	11·84	—0·35
THIRD NOTCH.	11	70	37	10·33	9·95	—0·38
	12	90	48	12·50	11·84	—0·66
Cutting off 13·8 Ins.	13	72	38	10·55	10·12	—0·43
	14	75	38	10·87	10·12	—0 75
Exhaust . . 20·8 ,,	15	79	38	11·33	10·12	—1·21
	16	65	33	9·78	9·24	—0·54
Expansion 1 to 1·5	17	55	28	8·65	8·35	—0·30
	18	72	37	10·54	9·95	—0·59
	19	89	33	7·90	8·30	+0·40
FIFTH NOTCH.	20	70	24	6·59	6·90	+0·37
	21	93	33	8·20	8·35	+0·15
Cutting off 8·8 Ins.	22	74	21	6·87	6·42	—0·45
Exhaust . . 18·8 ,,	23	80	22	7·29	6·58	—0·71
	24	63	17	6·08	5·76	—0·32
Expansion 1 to 2·14	25	55	15	5·52	5·43	—0·09
	26	65	16	6·24	5·60	—0·64
Mean of 1st Notch		79	54·60	14·65	14·21	—0·44
,, 3rd ,, ...		74	38·40	10·75	10·17	—0·58
,, 5th ,, ...		74	26·25	6·83	6·67	—0·16
1	2	3	4	5	6	7

TABLE No. 8.—*Of the Expansion and Water-Equivalents of Steam in the Outside-Cylinder Engines of the Caledonian Railway; abstracted from the Results of* 76 *Indicator-Diagrams, obtained in* 1850.

No. of Engine.	Cylinder.		No. of Notch.	Initial and Final Volumes by Expansion, clearance included, in Inches of Stroke.		Ratio of Initial and Final Volumes.	Observed Pressures during Expansion.		Equivalents of Water.			
	Diameter.	Stroke.		Initial.	Final.		Initial.	Final.	Initial.	Final.	Differences.	Ratio of Differences to Initial Equivalent.
	Ins.	Ins.	No.	Cub. Ins.	Cub. Ins.	Ratio.	lbs.	lbs.	Cub. Ins.	Cub. Ins.	Cub. Ins.	Per Cent.
No. 13	15	20	1	14·02	18·82	1·35	52	34	5·93	5·92	—0·01	— 0·2
" "			2	11·27	17·82	1·60	45	24	4·26	4·51	+0·25	+ 1·2
" 33	15	20	4	13·33	18·75	1·40	45	22	5·02	4·57	—0·45	— 9·0
" "			5	12·00	18·30	1·52	56	27	5·27	4·99	—0·28	— 5·3
" "			7	8·00	16·10	2·01	46	16½	3·12	3·38	+0·26	+ 8·3
" 41	15	20	1	15·50	19·60	1·26	36	24	5·07	5·00	—0·07	— 1·4
" "			2	14·20	18·60	1·31	26	16	3·84	3·82	—0·02	— 0·5
" 42	15	20	3	12·10	18·35	1·52	55	30	5·27	5·34	+0·07	+ 1·3
" "			4	10·10	17·10	1·70	49	22	4·06	4·16	+0·10	+ 2·4
" "			5	4·50	15·10	3·33	68	22	2·29	3·68	+1·39	+67·0
" 51	15	20	3	10·36	17·70	1·72	59	29	4·56	4·94	+0·38	+ 8·3
" "			4	7·10	15·50	2·20	50	20	2·91	3·63	+0·72	+25·0
" 125	17	24	2	18·80	23·80	1·27	33	20	7·48	7·20	—0·28	— 3·7
" "			3	14·90	23·00	1·54	48	26½	7·57	7·98	+0·41	+ 5·4
" "			4	10·20	22·10	2·16	37	18½	4·36	5·39	+1·03	+24·0
" 127	17	24	5	5·70	16·20	2·84	57	20	3·26	4·77	+1·51	+46·8
1	2	3	4	5	6	7	8	9	10	11	12	13

lines have been drawn on the diagrams on the principle which the writer has satisfied himself applies in the particular case of the indicator,—that action and reaction are equal, and that therefore the mean line, or radical form, ought to enclose the same collective area of diagram as the fluctuations in the lines actually described, due partially to momentum, cutting off at one place as much as it encloses at another.

From this it appears that for the greater ratios of expansion, the final equivalent of the steam is much above the initial, and the greater the ratio the greater is the per-centage of this excess, amounting to 67 per cent., with an expansion of 3½ times. This relation is just what was found for the slow diagrams from No. 13, and there is no doubt the excess of steam, at the termination of the expansion, is due to the same cause, namely,—the condensation of the steam in the cylinder during admission, and during the first part of the expansion, and the subsequent re-evaporation of a portion of the precipitated steam. During the experiments there was at all times ocular demonstration of the existence of water in the cylinder, in the spray which escaped from it through the indicator, and *which was given off more abundantly the more expansively the steam was worked.*

To find the general rate at which the per-centage of condensation increases in these engines with the degree of expansion, the results obtained above may be referred, as ordinates, to a base-line representing the ratios of expansion. Let AB, Fig. 4, Plate 62, be a base-line divided to represent the total volumes by expansion in terms of the initial volumes; and from B draw the vertical scale to measure the relative per-centages of condensation. From A set off on the base line the ratios of expansion, and for each ratio set off perpendicular distances by the vertical scale, equal to the respective per-centages of the differences of water-equivalents, col. 13, and define their extremities by points, setting off minus per-centages below the line, and plus per-centages above. The mean line CD, drawn through these points, is straight, and represents the mean rate at which the indicated condensation increases with the degree of expansion. It is found to meet the vertical from division 1, at 20 per cent. below, crosses the base-line at a volume of 1·53,

and terminates at E, the point due to an expanded volume of 3·4, and to a per-centage of 70, and would, if produced, meet the vertical from B, at 92½ per cent. The straightness of the line implies that the indicated per-centage of condensation increases uniformly with the relative volume by expansion. For an expansion of 1·53 times, the per-centage of condensation, or indicated difference of equivalents, is nothing; and, generally, for expansions advancing by half-volumes, the per-centages are as follows:—

Expanded Volumes, the Initial Volume being = 1.	Indicated Per-centages of Condensation.
1·5	— 1¼
1·53	0
2	17½
2·5	36¼
3	55
3·5	73¾
4	92½

For every half-volume of expansion there is an increase of 18¾ per cent. of indicated condensation, and this becomes so serious, that for an expansion of four times, if this were practicable with ordinary valves and link-motions, there would be 92½ per cent. of loss by condensation, or a loss of nearly one half of the total quantity of steam admitted.

For ready reference it is expedient to find the relative expansion and indicated condensation for different periods of admission, yielded by ordinary link-motions. The following table, No. 9, contains in col. 2 the total expanded volumes due by the nature of link-motion to the several periods of admission in col. 1, and col. 3 contains the relative indicated per-centages of condensation due to these expansions, measured from the diagram.

Though the losses shown in the 3rd column are great, the real losses must be still greater; because the restoration of condensed steam, by which the losses have been measured, cannot be entire. The indications, indeed, fail to show any loss at all, at 50 per cent., as the re-evaporation balances the condensation during expansion. For 75 per cent., the re-

TABLE No. 9.—*Of the Indicated Condensation of Steam in Outside Cylinders, during the Admission of the Steam.*

Period of Admission, in parts of the Stroke.	Total Volume by Expansion, the Initial Volume being = 1.	Indicated Condensation, in parts of the Indicated Steam cut off.	Approximate Proportion of Steam Condensed.	
			In parts of the INDICATED Steam consumed.	In parts of the WHOLE Steam consumed, (including the Condensed Steam.)
Per Cent.	Ratio.	Per. Cent.	Per Cent.	Per Cent.
75	1·22	— 12·0	12	11
60	1·40	— 5·2	12	11
50	1·54	0·0	12	11
40	1·78	9·4	21	17
30	2·07	19·9	32	24
20	2·45	34·1	46	32
12	3·17	61·1	73	42
1	2	3	4	5

evaporation (if any) is so slight as to leave a deficit of 12 per cent., by condensation, during expansion, compared with what was indicated as cut off. Now, the whole tenor of the evidence shows, plainly, that the degree of condensation increases as the admission is shortened; and it may be safely inferred that as 12 per cent. is shown to be lost in full gear, there is, at least, 12 per cent. of loss for 50 per cent. of admission, cutting off at half-stroke. An approximate loss of 12 per cent. will, on this ground, be adopted for all admissions greater than half-stroke; and 12 per cent. will also be added to the indicated losses for shorter admissions, as an approximation to the real conditions.

The most direct test of the amount of loss from condensation of the steam during expansion, appears to be the mode adopted above, of comparing the water-equivalents, or the actual weights of the steam present in the cylinder, at the beginning and at the end of the expansion.

An exact conclusion as to the amount of *condensation during expansion* cannot be obtained from the *loss of area* in the indicator diagram. The dotted line EFG added in Fig. 1, is not the curve that

would actually have been described had there been *no condensation*, but such as *might* have been described by the quantity of steam which the final pressure, during expansion, proves to have been admitted. The loss, by condensation, *could not have been less* than shown by the shaded area, but was certainly greater in amount, for it appears that a portion of the steam admitted, and sometimes a considerable amount of it, is buried for ever, and is not resuscitated at all at the end of the expansion. This is proved by the great increase of back pressure that takes place when a high degree of expansion is used, from the lower temperature of the cylinder, as illustrated by the diagrams in Fig. 9, which must have been caused by the quantity of precipitated steam still remaining in the cylinder after expansion.

Col. 4 contains the approximate losses as revised in the way above described, in parts of the *indicated* steam admitted. Adding the *lost* steam admitted to that indicated, the sum expresses the *whole* steam admitted and expended; and col. 5 contains the per-centage of approximate loss, expressed in terms of the wholo steam so used, which is a more convenient form for reference. From this column it appears that for 40 per cent. admission, 17 per cent., or one-sixth of the steam, is condensed; for 30 per cent., one-fourth; for 20 per cent., one-third; and for 12 per cent., or mid gear, two-fifths, or not far from one-half.

It must be added that the foregoing deductions are based on steam-pressures under 60 lbs., generally about 50 lbs. during admission. For higher pressures, and admissions above half-stroke, the condensation is proportionally less, as will afterwards be shown.

Proof of the condensation of steam in outside cylinders, by comparison of the indicated consumption of steam with the measured consumption of water.—Arguments for condensation based upon the measured consumption of water must be received with caution, because in some cases an excess of water passes off as "priming," without ever being evaporated at all. In the following discussion, care will be taken to avoid this source of error.

TABLE No. 10.—*Abstract of the working of the Passenger Engine No. 42, C.R., with Express Train, August,* 1850. *Cylinder* 15 × 20 *inches, Wheel* 6 *feet.*

Stations, Intermediate Distances, and times of Steam on.	Notch under which the Engine was worked.	Miles run under each Notch, with steam on.	Average Indicated Pressures at Cutting-off, under each Notch.
	No.	Miles.	lbs.
(1.) Glasgow to Motherwell, 16 miles, steam on, 30 min. Average admission 45 per cent. of stroke.	2	½	47
	4	5½	36
	"	5½	50
	"	3	72
		14½	
(2.) Motherwell to Carstairs, 15½ miles, steam on, 29½ min. Average admission 54 per cent.	3	10	69
	"	2¼	38
	4	2	50
		14¼	
(3.) Carstairs to Beattock, 34 miles, steam on, 38¼ min. Average admission 50 per cent.	3	9½	50
	4	11	50
	"	3	58
		23½	
(4.) Beattock to Carlisle, 39½ miles, steam on, 56¼ min. Average admission 40 per cent.	2	½	60
	3	3	60
	"	1¼	30
	4	12¾	38
	"	2	50
	"	1¾	33
	"	7½	52
	5	3½	30
	"	6½	56
		38¾	

For the purpose of testing this comparison, the following experiment was tried by the author on the actual consumption of water by an outside-cylinder express engine, No. 42, for a trip of 105 miles, from Glasgow to Carlisle, on the Caledonian Railway, with a train averaging 6½ carriages; the time of the trip being 3 hours 22 minutes, including five stoppages.

Indicator-diagrams were taken from the cylinder at intervals of one or two miles, and the notch of the expansion gear observed for each diagram, and the points of the line where each change of notch was made. The results are shown in the accompanying Table, No. 10.

The several points of cutting off, expansion, and compression were accurately ascertained by means of the slow diagrams; from which were calculated the exact quantities and pressures of sensible steam actually consumed in each interval of the trip, and the water-equivalents for the several quantities of steam present in the cylinder; which, multiplied by the number of strokes of the two cylinders in each interval, gives the total quantity of water efficiently used as steam.

The following final results were thus obtained:—

		Water used as Sensible Steam.	Water Consumed as Measured.	Excess.
1	Glasgow to Motherwell	30·76 ft.	35·82 ft.	5·06 ft., or 14 per cent.
2	Motherwell to Carstairs	43·91 „	48·85 „	4·94 „ or 10 do.
3	Carstairs to Beattock	57·28 „	67·74 „	10·46 „ or 15½ do.
4	Beattock to Carlisle	62·42 „	79·50 „	17·06 „ or 21¾ do.
	Total, Glasgow to Carlisle	194·37 ft.	231·91 ft.	37·54 ft., or 16¼ per cent.

The examination of the indicator-diagrams in the manner employed before, by comparing the initial and final water-equivalents of the steam during expansion, shows that at least 13 per cent. of this loss of 16¼ per cent. was due to condensation, and it is probable that no appreciable proportion was due to priming; indeed the *least loss* was observed to take place with the least degree of expansion.

and when the consumption of steam from the boiler is going on at the *greatest rate*, as we find on referring to the per-centages of admission in the first column of Table 10; which is the reverse of the effect that would be observed if priming were a material cause.

Experiments made by the writer with other outside-cylinder engines, *or imperfectly-protected* cylinders, corroborate the above deductions obtained from the performance of No. 42; and they are still further corroborated by his experiments on inside *well-protected* cylinders, which show that in ordinary good condition there is no sensible excess of water of any importance, actually consumed from the boiler, above what is estimated from the indicated steam passed through the cylinder. These results are also confirmed by the results of the trials of Mr. D. Gooch, with the "Great Britain" and similar engines.

The increased *back pressure of exhaust* affords additional evidence of the presence of water in the cylinder. The back exhaust pressure is the consequence of the want of facilities for the timely discharge of the exhaust steam from the cylinder; and the impediments to its discharge are much increased by the presence of water amongst the steam, whether due to condensation or to priming. The presence of water is immediately made apparent by the increase in the back exhaust pressure, shown by the indicator-diagram, as the writer has on many occasions had an opportunity of observing. The *effects of priming* from foulness of the water in the boiler are shown in Fig. 3, Plate 62: A and B are indicator-diagrams taken from the well-protected cylinders of the "Orion," in which very little, if any condensation could be detected. The diagram A was taken *before*, and the diagram B after the boiler was blown off and supplied with clear water, both being taken at the same speed, and showing 7 lbs. back pressure caused by priming in the former case.

The diagrams C and D, Fig. 3, Plate 62, show that the *total quantity of water* from condensation is considerably greater, with the greater degrees of expansion, where a *smaller quantity of steam* is admitted, and consequently the loss is more seriously felt. These diagrams were taken from the outside-cylinder goods engine No. 127, working at the same speed up and down an incline on the Caledonian Railway; the diagram C cutting off at two-thirds the

stroke, and the diagram D at one-sixth of the stroke. The latter. D, though it had the advantage of a much earlier exhaust, and only one-fourth of the quantity of steam to discharge, was affected with 10lbs. more back pressure than the former, C, when working in full gear. This great back pressure was maintained over a continued run of twenty miles, when of course the cylinders had got into their working heat for that degree of expansion; and the inference is that the steam was loaded with water of condensation. (proved also by the expansion-curve,) which was with difficulty expelled, and which only became proportionably less when the degree of expansion was diminished; and, consequently, the mass of steam increased that was to be cooled within the same superficies of cylinder.

That the *total mass of the steam* has much to do with the condensation is proved by the diagrams E and F, Fig. 3, Plate 62. taken under the same degree of expansion, and at the same speed, but with 75 and 20lbs. steam respectively admitted to the cylinder. In the latter diagram, F, the back exhaust pressure is 7lbs. greater than in the former diagram, E, although the total quantity of steam to be discharged was so much less In the latter case, indeed, there was found to be an excess of 18 per cent of the whole water used over the indicated steam expended, which was most probably altogether by condensation, as the rate of consumption was so moderate as to preclude any likelihood of priming.

Now here is a case where, in the same class of engines, the back exhaust pressure *increases* as the quantity of steam to be discharged *becomes less*, notwithstanding that the facility for exhaust increases at the same time. This is clearly a case of water in the cylinder, the quantity of which increases with the degree of expansion; and the water is as clearly a precipitation of steam by condensation. Also, though a full admission of steam at higher pressures may reduce the proportion of condensation, yet whenever expansive working is attempted by cutting off earlier, the heavy back pressure and the course of the expansion-line alike show that no pressure of steam, however high during the admission, can mitigate the evils of condensation in exposed cylinders.

Evidence from the proportions of the valve-gear.—The remarkable

inversion, just discussed, of our ordinary experience with well-protected cylinders, whereby the back pressure rises with the degree of expansion, leads to the necessity for more liberal proportions of valve-gear for outside cylinders, to afford a more free exhaust. The writer has invariably found that of the three fixed elements affecting the exhaust, namely, the sectional area of steam-port, the inside lead, and the area of blast-orifice, (so long as the port is larger than the orifice,) it is the orifice alone which in well-protected cylinders rules the amount of exhaust back pressure; the wider the orifice the less the pressure, in the ratio of the 4th power of the diameter of the orifice, or the square of the area; whereas, in exposed cylinders, the back pressure is ruled both by the orifice and by the inside lead; the greater the orifice, *and the greater the inside lead also*, the less is the pressure. This is an important distinction, because it shows that, as inside lead is equal to the sum of the lap and the outside lead, and is, in fact, regulated by the lap, the lap of the valve is a very important element in the designing of outside cylinders, though practically a matter of indifference in insides. Accordingly, it has been found that in Sharp's inside-cylinder engines, on the Edinburgh and Glasgow Railway, which have only a ⅝th-inch lap,—probably the shortest lap in present practice for a 15-inch cylinder,—the exhaust is as perfect as in the Caledonian passenger-engines with 1¼-inch lap for the same cylinder. Further, in inside cylinders with clean boilers, it is practically a matter of indifference what amount of wear or slugger may have taken place in the valve-gear, so far as concerns the exhaust: in outsides, on the contrary, it is a very important object to maintain the gearing in the highest order, so as to keep up the inside lead, as the wear of the gearing directly reduces the lead, and thereby increases the back pressure. The Caledonian is perhaps the first line in this country on which the special advantage of long lap for outside cylinders was experienced. Nor need there be any apprehension of reducing the tractive power of an engine by increasing the lap, and thereby shortening the period of admission, because the same admission may be obtained by increasing the lead and the travel of valve in the same ratio with the lap; and, it may be added, this may be simply done in existing link-motions, by extending the link

beyond the eccentric-rod ends, and thereby increasing the range of the sliding blocks, and the maximum travel.

The formidable degree of condensation which accompanies high expansion in partially-protected cylinders, accounts for the opinion held by men of experience of the inutility, for economical objects, of cutting off the steam earlier than at half-stroke, for the proved advantage of expansive working in inside cylinders is neutralised in outsides by the condensation. Mr. Buddicom, of the Rouen Railway, led the way in the re-introduction of outside cylinders in this country; and to this day, he, and some of his followers, have adhered to the fixed gab-motion.

Conditions on which the expansive working of steam in locomotives may be carried out with efficiency and success.—The first condition is to perfectly protect the cylinders, and to maintain them *at a temperature at least as high as that of the steam admitted to them.* Simple non-conducting envelopes are not sufficient; external *supplies* of heat must be employed, and the application of a steam-jacket to the cylinder would be advantageous, when other sources *of* heat are not readily available. The writer tried an experiment with the "Orion," Edinburgh and Glasgow Railway, which has its *cylinders* suspended in the smoke-box, like the "Great Britain's," in which, by the use of partitions, the hot air from the tubes was directed entirely round the cylinders, previously to its emerging by the chimney; but he could not detect the slightest change in the performance of the engine, probably because the hot air was really very little hotter than the steam, and the closer contact made no difference. For cylinders already well protected, more thorough modifications would be required to make a sensible improvement. The steam should also be surcharged, previously to entering the cylinder, by passing over an extensive heating surface, deriving its heat from the atmosphere of the smoke-box, or, if necessary, from a hotter source.

The writer has lately been favoured with the results of experiments made by Mr. W. C. Hare, of Stonehouse, Devon, on a small engine, with cylinder $3\frac{1}{4} \times 8$ inch stroke, and a boiler having 9 feet of heating surface. He employed a special coil of 40 feet of half-inch

copper tube, having $5\frac{1}{4}$ feet of inside surface, and heated by a circular row of very small gas jets. A small cock was fixed on the top of the boiler, close to the mouth of the steam-pipe, and by occasionally opening it when the engine was working, any priming, or even mere dampness of the steam, could be detected; and thus the experiments could be conducted with the assurance that the results were not affected by priming. When the steam was passed through this surcharging pipe, and was heated to 400° previously to its entering the cylinder, the consumption of water from the boiler was three gallons per hour; and when the communication with the surcharging pipe was cut off, and the steam led directly to the cylinder, the water used amounted to six gallons, or twice the other, while doing the same work, and involved a great increase of fuel consumed. To effect the economy here noted, from which something must be allowed for the consumption of gas, it appears that a surcharging surface equal to fully one-half of the heating surface has been necessary; and it is probable that for locomotives a considerable allowance must be made to produce a very decided change. The results of this experiment show that very much has yet to be done before the capabilities of the locomotive are fully developed.

As steam has been found so very sensitive to *exposure* on the one hand, and to *surcharging* on the other, it would probably be of advantage to *lead the hot smoke round the barrel of the boiler and the fire-box*, or the barrel only, *previously to its discharge by the chimney.* The barrel only would probably be enough to tell with good effect, and the hot air might be led either in a winding flue round the boiler, or, what would be better, led along the entire lower half towards the fire-box, and returned along the entire upper half to the chimney. If *all* the hot air were found too much, only a *part* of it might be diverted by partitions, or otherwise, from the upper or lower tubes.

The second condition of successful expansive working in locomotives is the combination of a sufficiently high boiler-pressure of steam, with suitable proportions of cylinder and driving wheel, to admit of highly expansive working consistent with the required duty of the engine. It is probable that 150 lbs. per inch is about

the highest pressure at which it is advisable to work a locomotive, consistent with the fair working and durability of its parts. The maximum pressure being settled, and it being assumed that the same pressure is to be maintained in the cylinder during admission, the degree of expansion to be adopted determines the capacity of the cylinder to develope the necessary average power. Long strokes are not advisable on the score of stability, at least for outside cylinders, and large diameters should rather be adopted; for the same reason, large wheels are preferable.

Thirdly, in the details of the mechanism, the cylinder should be arranged to have the shortest practicable steam-ways; as, for short admissions, a long steam-way deducts very much from the efficiency of the steam. Such an arrangement would be greatly promoted by the introduction of balanced valves, or such as have provision for preventing the steam-pressure on the back of the valve; as, by being balanced, they could with facility be made large enough to embrace the whole length of the cylinder. The loads which ordinary valves are forced to carry on their backs are enormous; and though there is certainly no momentum in these loads to contend with, yet the friction of surfaces due to the loads is very great, even at the most moderate computation.

In this attempt at an elucidation of the action of steam in the locomotive engine, the writer has endeavoured to keep constantly in view, that the proper observation and registration of facts supply the only sure basis on which principles of practical utility can be founded; as, in the conduct of investigations affecting the material laws of nature, the inquiry must be tempered with that consideration for practical necessities which cannot be disregarded with impunity.

Mr. Buckle observed that the Paper appeared to be prepared with great care, and was a valuable collection of practical information.

Mr. Crampton inquired whether it was intended in the Paper that outside cylinders could not be effectually protected?

He was aware there was a strong opinion amongst engineers that outside cylinders could not be properly protected, but he considered there was no impossibility in it.

Mr. Clark replied, it was only intended to be stated in the Paper, that the general effect in practice was, that outside cylinders were worse protected than inside cylinders, and they were generally very much exposed.

Mr. Buckle observed, that it was very important to have the cylinders of all engines well protected; this was particularly attended to in the Cornish engines, in which a casing nine or ten inches thick of non-conducting material was placed round the cylinders, besides a steam jacket. The proportion of expansion should be regulated by the kind of work to be done; pumping admitted of a great extent of expansion, the jolt and inequality of motion being of no consideration, but in grinding flour, spinning cotton, &c., a uniform motion was obtained by a moderate proportion of expansion, say from one-fifth to one-eighth, according to the work to be done; this arrangement, with ample passages to the cylinders to admit and exhaust the steam, produced a motion for machinery nearly equal in uniformity to a water-wheel.

Mr. Crampton thought that enough attention had certainly not been paid to the condensation in the cylinders of locomotives at slow speed; he did not think it was of so much importance at high speeds. It was also particularly of importance in steam-boat engines, where the question had not received so much attention as it deserved. He remembered an experiment which showed a remarkable effect of condensation: four condensing engines, of equal size, were working coupled together in a boat, with the steam cut off at one-quarter of the stroke and expanded; two of the engines were then disconnected, and the other two engines were worked, cutting off at half stroke, using, consequently, the same quantity of steam as the four engines did, cutting off at one-quarter of the stroke; but a greater effect was found to be produced by the steam than when it was used

in the four cylinders. This increase of effect appeared to be entirely due to the greater amount of condensation that took place in the four cylinders than in the two cylinders. There were no steam jackets, only ordinary clothing on the cylinders, and he thought much improvement was required in this respect in marine engines, and it was a matter well deserving the consideration of engineers.

In reply to an inquiry, he said the boilers were working with salt water, but he did not think that would affect the result.

Mr. Clark said he had found that even at the highest speeds in locomotives there was great condensation with high degrees of expansion, except in the case of well-protected inside cylinders.

Mr. Peacock suggested, that part of the effect in the experiment mentioned by Mr. Crampton might have been due to the smaller amount of friction in the two cylinders than in the four cylinders, when giving out the same total amount of power.

Mr. Crampton replied, that a greater effect was found to be produced after allowance was made for the friction, by taking indicator-diagrams, and the relative consumption of the water.

Mr. Whytehead thought the loss by back pressure would also be less in the case of the two cylinders than with the four.

Mr. Bovill enquired whether Mr. Crampton could give the result of any trials of the relative consumption of steam, with unprotected cylinders, and with steam jackets?

Mr. Crampton replied that he could not give the exact comparison.

Mr. E. A. Cowper exhibited an indicator-diagram, which he had obtained from a 35-horse-power stationary engine, cutting off at about $\frac{1}{4}$-stroke, and working expansively, on which he had drawn the true expansion curve, according to Pambour; the difference between the actual and the theoretical curve was a confirmation of Mr. Clark's observations, the actual curve having fallen below the theoretical at the commencement, and gradually risen a little above it at the latter part of the expan-

sion, from the temperature of the cylinder being higher at that time than the steam. The engine had an uncovered cylinder without a steam jacket, but was not exposed to the cooling action of passing rapidly through the air like a locomotive cylinder. He observed, that Mr. Stephenson had mentioned at the last meeting an experiment by Mr. Trevithick, in which he had found that one bushel of coal burnt under the cylinder did as much duty as five bushels of coal burnt under the boiler, showing the economy of keeping the cylinder warm.

A vote of thanks was then passed to Mr. Clark for his paper.

The following Paper, by Mr. Charles W. Siemens, of London, was then read:—

ON THE EXPANSION OF ISOLATED STEAM, AND THE TOTAL HEAT OF STEAM.

The object of this Paper is to lay before the Members the results of certain experiments on Steam, purporting, in the first place, to corroborate Regnault's disproval of Watt's law, "that the sum of latent and sensible heat in steam of various pressures is the same;" in the second place, to prove the rate of expansion by heat of Isolated Steam: and, in the third place, to illustrate the immediate practical results of those experiments in working Steam Engines expansively.

The Author pursued these experiments at long intervals since the year 1847, with no other object in view than to extend his own information; and, consequently, without pretence to generalisation or extreme accuracy. The question, however, is one of great practical importance to Engineers, and with the advantage of valuable suggestions and the co-operation of his friends, Mr. Edward A. Cowper and Mr. William P. Marshall, the Author has again taken up the experiments, which, having been referred to at the previous meeting by Mr. Cowper, he feels himself called upon to lay before this Institution in their present state, though incomplete.

The amount of heat required to convert one pound of Water into Steam of different pressures has occupied the attention of Natural Philosophers from the earliest periods of the modern Steam Engine.

Dr. Black observed, about a century ago, that a large quantity of heat was absorbed by water in its conversion into Steam (not accompanied by an increase of temperature), which he termed "the Latent heat of Steam." His apparatus consisted simply of a metallic vessel containing water, which he exposed to a very regular fire; and from the comparative time which was occupied, first in raising the temperature of the water to the boiling point, and, secondly, in effecting the evaporation, he approximately determined the *amount* of latent heat. Resuming the experiment, in conjunction with Dr. Irvine, he employed a different apparatus, consisting of a Steam Generator, and of a Surface Condenser, or a Serpentine Tube, surrounded by a large body of cold water.

The Steam which condensed in the Serpentine Tube was carefully collected and weighed, and the rise of temperature of the surrounding water was observed, which, multiplied by its known quantity, represented the total quantity of heat which the Steam had yielded.

The quantity of heat requisite to raise the temperature of one pound of water through 1° Fahr. being taken for the unit of heat, Black and Irvine obtained for the total quantity of heat in

Steam of atmospheric pressure, the number...	954
Southern	1021
Watt obtained the number	1140
Regnault	1145
Dr. Ure	1147
Desprer, 1136, but later	1152
Brix	1152
Gay Lussac and Clement	1170
Count Rumford...	1206

All of these eminent Experimentalists employed essentially the same apparatus, and the differences between their results proves its

great liability to error. Brix, of Berlin, was the first to investigate those errors, and to calculate approximately their effect upon the results obtained.

While such a large amount of labour and talent has been expended to determine the latent heat in Steam of atmospheric pressure, a far more important question seems to have been passed over with neglect, namely, What is the relative amount of heat in Steam of various densities?

The celebrated Watt justly perceived the importance of this question, but contented himself with one experiment upon which he based his law, "*that the sum of latent and sensible heat in Steam is the same under all pressures.*"

Southern repeated the experiment, and found that Steam of greater density contained absolutely more heat than Steam of lower pressure, which induced him to adopt the hypothesis that "*the latent heat of Steam was the same at all pressures.*"

Subsequent experiments and general reasoning seemed to be in favour of Watt's law, which enjoyed the general confidence until it was attacked, only a few years since, by Regnault, of Paris, who proved by a series of exceedingly elaborate and carefully conducted experiments, that neither the law of Watt nor that of Southern was correct, but that the truth lay between the two. The apparatus employed by M. Regnault may be said to be a refinement upon those previously employed, and with the advantage of Brix's labours to determine the amount of errors, he seems to have succeeded in measuring the absolute amount of heat in Steam of various pressures with surprising accuracy.

The costly and complicated nature of the apparatus employed by M. Regnault, has hitherto prevented other experimentalists from repeating the experiment, and in the meantime practical engineers still continue to adhere to Watt's law.

Shortly after the publication of Regnault's experiments by the Cavendish Society, in 1848, the idea occurred to the Author of the present paper that their results might be brought to a positive test by a simple apparatus, which he places before the meeting in operation, shown in Fig. 1, Plate 63. It consists of an upright

cylindrical vessel of tin-plate A, which is surrounded by an outer vessel filled with charcoal BB, or other non-conducting material. A Steam-pipe C, with a contracted glass vein D, enters the inner vessel in a slanting position, in order that the water of priming from the boiler, and of condensation within the pipe, may return to the former, allowing only a small jet of pure steam to enter the vessel, where it suddenly expands and communicates its temperature to the bulb of a thermometer E, which is inserted through a stuffing-box from above. The lower extremity of the inner vessel A is connected on the one hand to a mercury gauge G, and on the other to a condenser, by means of a stop-cock to regulate the pressure. The pressure and temperature of the Steam within the boiler being known, and the temperature of the expanded steam observed, it will be seen whether that temperature coincides with the temperature which is due to pressure indicated by the mercury guage. If it did, then Watt's law would be confirmed, but since the temperature rises higher than is due to the pressure, it follows that the high-pressure Steam contains an excess of heat, which serves to *super-heat* the expanded Steam. All losses of heat from the apparatus would tend to reduce the temperature, and be in favour of Watt's law; but it will be shown that those losses may be entirely eliminated, and a true quantitative result be obtained. For this purpose the pressure in the boiler should first be raised to its highest point, and the indicating apparatus be well penetrated by the heat; the fire under the boiler should thereupon be reduced, and observations made simultaneously, and at regular intervals, of the declining pressure within the boiler, and temperature of the expanded Steam of constant pressure. The pressures being nearly equal, the fire under the boiler is again increased, and the observations continued until the maximum pressure is once more obtained; and the loss of heat by radiation, &c., may be correctly estimated, by a comparison of the two series of observations.

The second portion of this paper relates to the rate of expansion of Isolated Steam by heat, that is, steam isolated from the water from which it is generated.

The Author has not been able to meet with any direct experiments on this subject, except some at a recent period by Mr. Frost, of America, which, however, do not seem entitled to much confidence. The rate of expansion of air and other permanent gases by heat was first determined by Dalton and Gay Lussac simultaneously, who determined that all gases expanded uniformly, and at the same absolute rate, amounting to an increase of bulk equal to $\frac{1}{480}$th part of the total bulk at 32° Fahr. for every one degree Fahr., or $\frac{1}{660}$th part of the total bulk at 212°. Dulong and Petit confirmed the law of Dalton and Guy Lussac, but it appears that these philosophers confined their labours to the permanent gases and atmospheric pressure, and merely supposed the general applicability of their discovery.

Being interested in the application of "super-heated" Steam, the Author tried some direct experiments on its rate of expansion, in the year 1847, which confirmed his view, that vapours expand more rapidly than permanent gases, or in other words, *that the rate of expansion of different gases and vapours is equal, not at the same absolute temperature, but at points equally removed from their point of generation.*

The apparatus employed in these experiments has been placed before the meeting, and its simplicity, when seen in operation, is such that the result, it is hoped, can hardly be doubted.

It is shown in Fig. 2, Plate 63, and consists of a metallic trough AA, containing oil, which is placed upon a furnace BB, heated by gas flames. One end of the trough is provided with a stuffing-box, through which a glass tube C, of about $\frac{1}{16}$th inch diameter, and sealed at one end, may be slipped, which will rest horizontally upon a scale below the surface of the oil. The mouth of the glass tube is connected to an open mercury syphon G, with either the one or the other leg filled with mercury, to produce the desired pressure within the horizontal glass tube. A small drop of water and a piston of mercury P being introduced into the bottom of the tube, it is placed in the oil bath, and connected to the syphon. The oil bath is then gradually heated, and the temperature observed. As soon as the boiling point of water under the pressure in question is reached, the mercury piston will move rapidly

forward, until all the water is converted into steam. The temperature continuing to increase, the piston will continue its course more slowly upon the scale, where its progress is noted from time to time, together with the temperature.

The experiment is continued until the temperature reaches about 400°, when the oil begins to boil. The gas flame is then withdrawn, and the bath allowed to cool gradually. The observations of the temperature and the position of the mercury piston are continued until the Steam contained behind it is recondensed. A comparison between the two series of observations gives the correct mean of the experiment, by which the effects of the friction of the mercury piston, any possible slight leakage of Steam past it, and faults consequent on the slow transmission of heat, are completely neutralized.

The curve A on Fig. 3, Plate 64, has been drawn, expressing the rate of expansion of atmospheric Steam according to these experiments. The results of nine separate experiments very nearly coincide, (as shown by the dotted lines, which give the extreme variation in the experiments,) except at the starting point, where the rate of expansion is so very great that it is difficult to obtain correct observations; changes in the barometer, moreover, affect the curve in the vicinity of the boiling point. To obviate the effect of these inaccuracies, the unit of volume in laying down the curves from each of the nine experiments was taken, not at the absolute boiling point, but at 250°, where the expansion had already assumed a definite course.

The diagram also shows a *straight line* B, expressing the rate of expansion of common Air, which at first diverges greatly from the hyperbolic curve of expansion of steam, although the assymptote of the latter seems to run parallel to the former. The Author considers it therefore highly probable, "*that the rate of expansion of all gases may be expressed by one hyperbola, which starts from the condensing point of the gas,*" and that the apparently uniform rate of expansion of the permanent gases may be accounted for by their great elevation, at the ordinary temperature, above their supposed boiling point, in consequence whereof the true curve approaches so nearly to its assymptote that the difference cannot be detected by experiments.

The general result obtained from the above experiments may be stated as follows: that Steam generated at 212°, and maintained at a constant pressure of one atmosphere, when heated out of contact with water to

230°	is expanded	5	times more than Air	would be.
240°	ditto	4	ditto	ditto.
260°	ditto	3	ditto	ditto.
370°	ditto	2	ditto	ditto.

The Author intends to extend the range of his experiments upon gases and vapours under high pressure, and will be glad to communicate the further results to the Institution.

The diagram contains another curve, C, showing the results of Mr. Frost's experiments, alluded to before, which, from the very sudden and irregular rise at the commencement, appears to be affected by some serious source of error.

The two curves of *pressure* and *density*, P and D, show the rate at which *saturated Steam* increases in pressure and in density, with the rise of temperature marked at the bottom of the diagram. It will be observed that the pressure increases at a rather greater rate than the density; and it is a remarkable circumstance, that the difference, or the rate at which the pressure increases faster than the density, which is in effect the rate of *expansion of saturated Steam* with the increase of sensible temperature, *exactly coincides* with the line B, representing the rate of expansion of Atmospheric Air.

An extension of our knowledge on the properties of Steam is a matter of such evident importance to Engineers, that it would be useless to dwell upon its practical importance. Suffice it to say, that it has been theoretically demonstrated that a perfect Boulton and Watt Condensing Engine (abstracting friction and all losses of heat in the furnace and through radiation) would only yield about seven per cent. of the mechanical force which would be equivalent to the expanded heat. It may be argued from this, that the Steam Engine is destined to undergo another great modification in principle, and in the Author's humble opinion this crisis will be

accelerated by inquiries into those properties of gaseous fluids which have hitherto excited but little attention, and especially into the properties of Dry Steam, or Isolated Steam.

The present Paper will be confined to showing the effect of the above experiments upon the rate of Expansion of Steam within the Steam Cylinder of an Engine. It was demonstrated by the first-named experiments, that *Expanded Steam is Super-heated Steam;* and, by the second, it is shown what is the expansion of bulk due to an increase of temperature.

Supposing the results of the experiments to be correct, the expansion curve as laid down by Pambour, and which is based upon Watt's law, requires a modification due to the excess of temperature in Expanded Steam; and it will be observed that this correction in the curve of expansion is in favour of working engines expansively, as a greater average pressure is obtained during expansion than would be the case if the expanded steam were not thus super-heated. Its correctness is corroborated by some actual observations by Mr. Edward A. Cowper in taking diagrams of expansive engines, previous to his acquaintance with the above experiments. It moreover appears that in Cornwall, Engineers have been practically acquainted with the fact, that Expanded Steam is Super-heated Steam, and more economic in its use than Saturated Steam; for it is a practice with them to generate the Steam at very high pressure, and to expand it down to the required pressure previous to its reaching the Steam Cylinder.

Another remarkable practical observation is, that a jet of high-pressure Steam does not scald the naked hand, while a jet of low-pressure Steam does, although the high-pressure Steam is the hotter substance. The cooling effect of a jet of high-pressure Steam is so powerful, that, as the Author has been informed, ice has been actually produced in the heat of summer in America, by blowing a powerful jet of Steam of 400 lbs. pressure per square inch against a damp cloth. This phenomenon may be explained by the perfectly dry and under-saturated state of Expanded Steam, which, with a strong tendency to re-saturate itself, produces a powerful evaporation on moist surfaces with which it comes in contact.

The rapid rate of Expansion of Steam by heat, when still near

Table of Experiments on the Expansion of Isolated Atmospheric Steam.

Temperature Fahrenheit Degrees.	1 Ascending	2 Descending	3 Descending	4 Ascending	5 Descending	6 Ascending	7 Descending	8 Ascending	9 Descending
209	05·0	...	...	...	...	...	...	...	...
210	5·00	...	...	...	...	...	...	...	...
212	8·00	8 00	...	10 00	9 70	...	8·00	...	9 04
213	...	...	10·00	...	...	...	...	...	...
214	...	8·40	10·40	...	10 05	...	9·50	...	...
215	8·80	8·68	10·52	10·12	10·16	...	9·90	...	9·30
217½	9·00	8·90	10 66	10·20	10 32	...	...	9·30	9·45
220	9·10	9·11	10·84	10·30	10·50	...	10·50	9 50	9·57
222½	9·22	...	10 94	10·48	10 61	...	...	9 60	9 65
225	9·32	9·34	11·01	10·53	10·70	...	10 70	9·68	9·74
227½	...	...	11·11	10·60	...	...	...	9·75	...
230	9·54	9 58	11·21	10·68	10·86	...	11 00	9·81	9·91
232½	...	...	11·29	...	...	...	...	...	...
235	9·68	9·70	11·34	10·84	11·00	...	11·16	9·95	10·02
240	9·80	9·85	11·46	10·94	11·12	...	11·34	10·06	10·13
245	9·94	9·96	11·58	11·04	11 23	...	11·49	10·19	10·23
250	10·10	10·05	11 70	11·18	11·35	...	11·60	10·29	10·33
255	10·21	10 15	11·80	11·30	11·47	...	11·71	10·40	10·44
260	10·31	10·25	11·90	11·40	11·59	...	11·83	10·50	10·54
261	...	...	...	...	...	11 90	...	...	...
265	10·41	10·35	12·00	11·51	11·70	...	11·94	10 60	10·64
268	...	...	...	...	...	12 10	...	...	...
270	10·51	10·44	...	11 61	11·80	12·18	12·08	10·70	10·75
275	10 60	10·53	...	11·73	11·91	...	12·16	10·80	10·85
278	...	...	...	...	...	12·30	...	...	...
280	10·70	10·62	...	11·85	12·02	12 35	12·28	10·90	10·96
284	...	...	...	...	...	12·45	...	...	...
285	10·80	10·72	...	11·98	12·14	...	12·40	11·00	11·06
290	10·90	10·81	...	12·10	12·26	12·55	12·50	11·10	11·17
294	...	...	...	...	...	12·64	...	...	...
395	10·98	10·91	...	12·20	12·39	...	12·60	11·20	11·27
298	...	...	...	...	...	12·75	...	...	...
300	11·08	11·01	...	12 30	12·50	12·79	12·70	11·30	11·38
305	11·18	11·11	...	12·40	12·58	12·88	12 80	11·40	11·48
310	11·26	11·21	...	12·51	12·69	13·00	12·95	11·50	11·58
315	11 36	11·31	..	12·62	12·80	13 10	13 08	11·60	11·69
320	11·46	11·42	...	12·73	12·90	...	...	11·71	11·79
325	11·56	11·52	...	12·85	13·02	...	...	11·81	11·89
330	11 63	11·64	...	12·98	13·15	...	...	11·91	11·99
335	11·73	11·75	...	13·10	13·25	...	...	12 02	12·08
340	11 83	11·85	...	13·21	13·36	...	...	...	...
345	11·93	11·95	...	13·33	13·41	...	...	...	...
350	12·02	12·05	...	13·48	13·50	...	...	...	...
355	12·11	12·15	...	...	...	...	...	...	...
360	12·20	12·26	...	...	...	...	...	...	...
365	12·30	12·40	...	...	...	...	...	...	...
370	12·40	12·50	...	...	...	...	...	...	...
375	12·50	12·55	...	...	...	...	...	...	...
380	12·60	12·60	...	...	...	...	...	...	...

its boiling point, proves the economy of heating the Steam Cylinder either by a Steam jacket, or by the application of fire. It is, however, important to observe, that the specific heat of Steam seems to diminish, the more the temperature exceeds the boiling point. The annexed table of observations gives the data from which the curve A in Fig. 3 has been drawn.

Mr. Siemens explained the action of the two instruments, and showed their process in operation.

Mr. Crampton enquired whether the charcoal in the casing of the instrument would not get heated by the tube of high-pressure steam passsing through it during the experiment, and so super-heat the steam in the internal cylinder?

Mr. Siemens explained, that it was not possible for such an effect to take place, as the end of the steam-pipe was exceedingly small, and was protected by a thick non-conducting casing. He had also observed several times during the experiments, that whenever any priming took place in the boiler, and a drop of water came out with the steam, and fell on the bulb of the internal thermometer, the mercury fell immediately to 212°, or the boiling point of water, and remained steadily there for four or five minutes, until the whole of the priming water was converted into steam, when the mercury again gradually rose to its former temperature. This showed that the increased temperature above 212° in the internal cylinder was entirely due to the extra heat in the expanded high-pressure steam, and not to any heat derived from the charcoal casing.

Mr. Crampton remarked, that from the larger proportion of the steam-tube shown in the sketch, it had appeared to him that heat would be communicated to the casing; but from the explanation given, and the manner in which Mr. Siemens conducted his experiments, he had no doubt of the good results obtained.

Mr. E. A. Cowper observed, that the only source of heat to raise the temperature of the charcoal casing, was the super-heat

in the expanded steam in the interior of the cylinder, as the jet of high-pressure steam was so small and well protected, that it could not have any appreciable effect in heating the charcoal. Consequently, the charcoal casing could only attain the temperature of the expanded steam that was passing through it, and could not influence the temperature of that steam. In the first experiments tried by Mr. Siemens and himself, the lower end of the cylinder was entirely open to the atmosphere, so as to try the experiment with steam expanded down to the atmospheric pressure; and as the expanded steam was passing out into the atmosphere in a constant stream from the open mouth of the cylinder, it was impossible there that the increased temperature maintained in the cylinder could have been affected by the charcoal casing, and it could only have been due to the extra heat contained in the high-pressure steam.

Mr. Siemens said, that as a check on the accuracy of the observations, he had tried them successively in an ascending and a descending series, when any error from the source alluded to would have been made apparent, and been doubled in effect, but he could not detect more than one degree difference in the observations.

The thanks of the meeting were voted to Mr. Siemens for his paper and experiments.

The following paper, by Mr. Charles Cowper, of London, was then read:—

ON BOURDON'S METALLIC BAROMETER, INDICATOR, AND OTHER APPLICATIONS OF THE SAME PRINCIPLE.

Various instruments have been invented and employed for Measuring the Pressure of the Atmosphere, and also for Measuring the Pressure of Steam and other Fluids, but they may be divided into three principal classes.

In the first of these, the pressure is ascertained by measuring the height of the column of mercury which it is capable of sustaining, as in the common Barometer and the ordinary Mercurial Pressure-gauge.

In the second class, the pressure of the air or other fluid is ascertained by the amount of compression which it is capable of producing in a portion of air confined in a bent tube or syphon, by a portion of mercury or other liquid. The Sympiesometer and the Short Mercurial Steam Gauge are constructed on this principle.

The third class consists of a cylinder and piston, the piston being attached to a spring; Watt's Indicator is constructed on this principle, and it has also been proposed to employ it as a Barometer, by exhausting the air from the interior.

The difficulty of obtaining an air-tight piston, sufficiently free from friction, appears to have led M. Conté, at the latter end of the last century, to propose the application of a shallow air-tight box, covered with a thin metallic diaphragm, and exhausted of air. The diaphragm was supported by springs contained within the box, so that it rose and fell with the variations in the pressure of the atmosphere. The instrument known as the Aneroid Barometer is constructed in a similar manner, and the small motion of the diaphragm is greatly multiplied by means of levers. A similar instrument was constructed by M. Bourdon, as long since as the year 1843, for the purpose of a steam gauge. After many experiments, however, he laid it aside, as he found that the metal cracked after a continued use, and rendered the instrument useless.

The invention of the Instruments which are the subject of the present Paper, was the result of a careful observation of an accidental circumstance. M. Bourdon had occasion to restore the form of a worm-pipe of a still, which had been accidentally flattened. To effect this, he closed one end and forced water in it at the other end. The flattened tube expanded to its proper form, but at the same time M. Bourdon observed that the tube uncoiled itself to a certain extent, and it occurred to him to apply this fact to the construction of a Pressure-gauge. He did so, and with perfect success.

The principle of the Instruments will be best explained with the aid of the accompanying diagrams, Plate 65.

Fig. 1 is a section, and Fig. 2 a front view of a flattened metallic tube, bent into a circular form. If a pressure of steam or other fluid be applied to the interior of this tube, it will be found to uncoil itself as the pressure increases until it assumes the form shown in Fig. 3, and on removing the pressure it will return to its original form. If it is exposed to external pressure, or if the air is withdrawn from the interior, the tube coils itself up to a smaller diameter, as shown in Fig. 4. It will be found that as the tube uncoils itself it becomes thicker, from the sides becoming more convex, and as it coils itself up it becomes thinner. It is upon this relation between the thickness of the tube and the diameter of the coil, that the action of the instrument depends.

If a flat band of metal is bent round into a circle, its transverse form remains unaltered, but if a semi-cylindrical, or gutter-shaped band, like that shown at A, in Fig. 5, is bent into a circular form, its convexity is diminished, as shown at B, and if the circle to which it is bent is of small diameter, the band will become almost flat in the transverse direction.

The same effect takes place with a complete tube as with the gutter-shaped band, and it is owing to this peculiarity that tubular bodies possess such great rigidity. In fact, it is a law of general application, that a surface which is curved in two directions cannot have its curvature increased in one direction without diminishing its curvature in the other direction, and *vice versa*.

A tube may be considered as an assemblage of separate parallel filaments or wires, and if a curved gutter-shaped assemblage of wires, as shown in Fig. 6, is flattened out, it assumes the form shown in plan in Fig. 7, from the central wires being longer than those at the sides, owing to their having originally formed a portion of a larger circle. If on the other hand the gutter be curved to a smaller diameter, the ends will become hollow instead of round. As these effects cannot take place in a gutter-shaped band formed of one piece of metal, it becomes necessary for the different parts to accommodate themselves to the varying curvature in some other manner. This is effected by the change

in the thickness of the tube, which allows the two sides to assume a greater degree of convexity in the transverse direction, in proportion to the diminution of their curvature in the longitudinal direction.

The converse of this proposition equally holds good, that is to say, if pressure is applied to the interior of a curved tube B of a flattened section similar to that shown in Fig. 8, the effect is to separate the two sides of the tube in the direction of the line AC, and thus to increase their convexity in the transverse direction, as shown at D. The consequence is the diminution of their curvature in the longitudinal direction, as shown at E.

From these considerations it follows that a curved tube of cylindrical or circular section will not experience any change of curvature, when submitted to internal pressure, as the circle is the sectional form which all tubes tend to assume when exposed to internal pressure. As the sectional form therefore cannot alter, the longitudinal curvature ought also to remain unchanged. This theoretical observation is confirmed by actual experiment, the curved tube of circular section remaining unaltered in form when submitted to internal pressure. The result is the same with external pressure, provided of course that the pressure is insufficient to totally collapse and destroy the tube.

The mutual dependance of the two curvatures on one another is also proved in the following manner. When the flattened tube is embraced by a series of separate small clamps, of the form shown in Fig. 9, so as to prevent its sectional form from altering on the application of internal pressure, the consequence is that its longitudinal curvature also remains unchanged.

On the other hand, when the two ends of the tube are joined so so as to complete the circle, and the pressure is then applied, the consequence is that the tube, being unable to alter its longitudinal curvature, remains also unaltered in thickness.

The variation in the thickness of a curved flattened tube with variations of curvature is proved by actual measurement.

This variation is proportional to the change in its curvature, and *vice versa*. Thus, in Fig. 10, ABCD represents a curved

flattened tube, the arc AB having a radius of 60 parts, and the arc CD having a radius of 50 parts, the interval AC or the thickness of the tube being 10. If the arc AB is brought closer to CD by the application of external pressure, the arc AB will necessarily be too long for its new position. To establish the proper relation between the two arcs, their respective radii must still maintain their original relative proportion, or in other words, if the distance AC is reduced to eight parts or diminished one fifth, the radii must also be diminished one fifth each, and reduced to forty-eight and forty parts respectively. The length of the arc remaining constant, while the diameter is reduced, the radii will necessarily form an angle one fourth larger than in the original position, that is to say, if the original angle was sixty degrees, it will now be increased to seventy-five degrees. In Fig. 11 the dark lines show the original form, and the dotted lines show the effect produced by approaching the two arcs together. Fig. 12 shows the new form acquired by the tube.

The change in thickness of the tube is thus proportioned to the variation of its radius of curvature, and it is found by experiment that the motion of the extremities of the tube is proportional to the pressure applied, so that the indications are equal for equal increments of pressure.

This fact is of considerable importance, as it greatly facilitates the application of the principle to the construction of pressure-gauges, barometers, and other instruments.

The simplest form of these instruments is the Steam Pressure-gauge, Figs. 16 and 17, Plate 66, in which rather more than one convolution of flattened tube AA is employed. One end of this tube is fixed to a stop-cock B, in connection with the steam boiler, and the other end carries an index C, the extremity of which traverses over a scale graduated to pounds pressure per square inch. In some cases a small slider or an additional loose hand is added, which is pushed forward by the motion of the index, and serves to register the maximum or minimum pressure.

In another form of the instrument, the flattened tube is fixed at the top, and makes one turn, and the free end is connected by

a link to a lever and index. These instruments serve equally well as pressure-gauges and as vacuum-gauges. The dimensions of the tube and scale are varied according to the pressure to which they are to be exposed, and the degree of delicacy required in the indications.

This instrument answers perfectly for fixed engines, but if its position is varied by laying it on its side, the weight of the tube causes it to spring a little, and thus to interfere with the accuracy of its indications. Therefore, in cases in which the position of the instrument is exposed to variation, as in seagoing vessels, it is preferable to employ a circular tube fixed in the centre to the stop-cock, and having its ends connected by links to the two ends of a lever, turning upon a centre, and carrying the index. The two branches of the tube are thus made to balance each other, and the index being also balanced, the instrument may be placed in any position without its indications being thereby affected.

When a great range of motion is required, the lever is not placed on the axis of the index, but carries a toothed segment which drives a pinion on the spindle of the index.

Figs. 18 and 19 show a Pressure-gauge constructed in this manner. The bent tube AA is fixed in the centre, and the two branches of the tube are made to balance each other. The lever B to which they are connected gives motion to a toothed sector C, which is also balanced, and which drives a pinion on the axis of the index D, which is balanced.

This arrangement is well adapted for Barometers, in which case the air is exhausted from the flattened tube, which is then soldered up. The pressure of the atmosphere acts on the exterior, and is balanced by the elasticity of the tube, which varies in curvature with every variation in the pressure of the atmosphere. In order to prevent any slackness in the different joints from affecting the accuracy of the indication, a small hair-spring may be attached to the axis of the index, which will keep a slight tension upon all the joints, and keep the teeth of the pinion always in gear with the same side of the teeth of the sector. The Barometers are constructed with broader and thinner tubes than the steam pressure-gauges, as the variations of pressure to which they are subjected

being comparatively small, it is desirable to obtain a considerable motion with these small variations of pressure.

Fig. 13, Plate 65, is the section of tube which is generally employed for Barometers, while Figs. 14 and 15 are generally employed for steam pressure-gauges.

In order to give some idea of the extent of motion which is readily obtainable in these instruments, the following experiment may be mentioned. A tube of the sectional form shown in Fig. 13, and about three inches wide, was bent into a circle of about ten inches diameter. One end of the tube was closed, and a small tube attached to the other extremity. By placing this tube to the mouth, and blowing into the tube, it was caused to expand, and by sucking out the air the tube was made to contract. The motion thus produced in the free end of the tube was fully three inches. In the Barometers in which a tube about one inch wide is bent into a circle of about four inches diameter, the motion caused by exhausting the air from the tube is about an inch, but varies according to the sectional form and thickness of the metal which forms the tube.

If the curved flattened tube be filled with alcohol or other liquid, and hermetically closed, the instrument becomes a Thermometer, showing, by the motion of the index, every change in the volume of the enclosed liquid. The tube, being formed of metal, has the advantage of transmitting the heat to the enclosed liquid with greater rapidity than is the case with a glass Thermometer. In some cases, however, as in ascertaining the temperature of corrosive liquids, it might be advisable to employ a tube of glass.

A Pyrometer, for measuring high temperature, is made by connecting one of the pressure-gauges by a small platinum tube to a hollow ball of platinum, filled with air. The platinum ball being exposed to heat, the elasticity of the air contained in it is increased, and its pressure is indicated by the pressure-gauge.

If in place of *bending* the flattened tube, it is *twisted*, by fixing one end and turning the other round, a sort of quick threaded screw is obtained, which has the property of untwisting itself when acted on by internal pressure, and *vice versa*. The action of the twisted tube depends upon the same law which has already been

enunciated, namely, that a surface which is curved in two directions cannot have its curvature increased in one direction without diminishing its curvature in the other direction. In fact, if any portion of the surface of the twisted tube be examined, it will be found to be curved in two directions, but in place of the two curvatures being at right angles to one another, they form an angle more or less acute. The motion of the twisted tube is indicated by a hand fixed to its extremity, or the motion is increased by means of gearing or levers.

A Thermometer made by filling one of these twisted tubes with alcohol or other liquid, and provided with a float, as shown in Figs. 20 and 21, is convenient for enabling brewers and others to ascertain the temperature of large quantities of liquid. The thermometer is allowed to float in the liquid, and the temperature is read off on the dial, without the necessity of lifting the instrument out of the liquid.

All the applications of which these instruments are susceptible need not be mentioned; a few, however, may be alluded to, as illustrating the others.

By applying a tube of suitable dimensions, in connection with a steam boiler, it may be made to open and shut the damper, and thus regulate the pressure in the boiler. A similar arrangement with a Thermometer serves to regulate an Arnott's stove or a furnace.

A steam-engine Indicator is made by removing the cylinder piston and spring of an ordinary Indicator, and substituting a bent or twisted tube. Fig. 22 is a front view, partly in section, and Fig. 23 is a side view of such an Indicator. The bent tube A is placed at the lower part, and connected by a short link to a long lever, which carries the pencil B at its upper end. The paper or card is fixed on a brass plate C, which slides up and down on a fixed guide, and is moved by a pinion working into a rack on the back of the plate. This pinion carries a pulley D upon its axis, which is driven by a string from the beam or parallel motion of the engine. This pulley can be removed, and replaced by others of different diameters; this gives great facility in the application of the Indicator to different engines, especially to direct-acting

engines, where the motion may be taken at once from the cross-head by employing a large pulley. The pulley and pinion are mounted on a spindle passing through a fixed hollow pin. A spiral spring is attached to the fixed pin, and enclosed in a flat circular box, which fits in a cavity in the side of the pulley; this spring serves to keep the string always in a state of tension.

The long lever which carries the pencil turns on a fixed pin at bottom, and prevents the pencil from being moved out of its course by the friction of the paper against it, which might happen if the pencil were attached at once to the tube. The ends of the figure drawn on the paper are slightly curved, and it is necessary to measure the figure with a curved scale of the same radius as the lever.

To show that the principle may be carried out on a still larger scale, M. Bourdon has constructed a single-acting Steam Engine, in which a curved flattened tube made of two steel plates is employed in place of the cylinder and piston. This engine is shown in Fig. 24. One end of the tube A is fixed, and the other is united by a connecting-rod to a crank B, and fly-wheel. A slide valve C, is attached to the fixed end of the tube, and worked by an eccentric D, on the crank shaft. The steam is thus alternately admitted and discharged from the tube, and the engine has thus been worked at a speed of several hundred strokes per minute. To avoid unnecessary loss of steam, the tube is filled with oil, so that the steam only enters a portion of the tube, equal to the increase of its capacity produced by the pressure of the steam. The moving end of the tube A is guided by the lever E, which is adjusted to move in the natural path of the end of the tube without causing any strain. The crank B is slotted with a moveable crank-pin for varying the length of stroke, according to the pressure and the corresponding extent of motion of the tube. When the engine is non-condensing, the crank is set a little past the centre when the engine is at rest, but when the engine is condensing, it is set near half-stroke when at rest, as the tube expands with the steam-pressure, and collapses with the vacuum. The piston friction is avoided in this engine, and it may therefore be found economical for small engines.

In all cases in which accuracy of indications is required in the pressure-gauges, it is advisable to prevent the steam from entering the bent tube, whose elasticity would be reduced as long as it remained in a heated state. This is readily effected by causing the pipe which connects the gauge to the boiler or engine to *descend* to the gauge, as shown at E in Fig. 16: it will then always remain full of condensed water, and the gauge tube will be kept cool.

Mr. C. Cowper exhibited specimens of the different instruments and models, illustrating the principle of action. He said the steam gauges had come into extensive use in France, and he understood they were found very satisfactory and trustworthy; they were employed by the Government inspectors to test the pressure of steam boilers throughout that country.

Mr. Buckle observed that they appeared most useful gauges for general application, and well suited to many different purposes in practice.

Mr. Peacock said he had made trial of a pair of these steam gauges for the last eight months, on the boilers of a steam boat, working at 25 lbs. pressure, and he had found them quite satisfactory; they had not gone wrong at all during the time, nor had the index taken any permanent set.

Mr. C. Cowper remarked that the application of the principle to a steam engine had not been carried out on a large scale; an engine of about half a horse power had been made to show the application, and had been sent to the Exhibition. The different instruments could be inspected afterwards and obtained at Mr. Dewrance's office in London.

A vote of thanks was passed to Mr. Cowper for his communication, and the meeting then terminated.

[Mr. McConnell having been obliged to leave before the termination of the meeting, the Chair was then taken by Mr. Buckle.]

INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

HELD IN BIRMINGHAM, ON 28TH JULY, 1852.

JOSEPH WHITWORTH, ESQ.,
IN THE CHAIR.

BIRMINGHAM:

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1852.

PROCEEDINGS.

The General Meeting of the Members was held at the house of the Institution, 54, Newhall Street, Birmingham, on Wednesday, 28th July, 1852; Joseph Whitworth, Esq., in the Chair.

The Minutes of the last General Meeting were read and confirmed.

The Chairman announced that the Ballot Papers had been opened by the Committee appointed for the purpose, and the following new Members were duly elected:—

Members:

William Froude, Dartington, Totness,
William L. Kinmond, Montreal, Canada,
Thomas Ledger, London.

The discussion, adjourned from the last meeting, was then resumed, upon the Paper by Mr. Andrew J. Robertson, of London:—

ON THE MATHEMATICAL PRINCIPLES INVOLVED IN THE CENTRIFUGAL PUMP.

The general result arrived at by the investigation in this Paper (see Report of Proceedings, 29th June, 1852) was that centrifugal action is not an economical mode of applying power for raising water, and that the *theoretical limit* to the *useful effect* to be obtained by centrifugal action alone, is 50 per cent. of the *power* employed; a loss of 50 per cent. of the power being caused by the absorption of power in the *tangential* velocity given to the water, whilst the *radial* or centrifugal velocity alone is effective in raising the water. But the *practical limit* of the *useful effect* is reduced to 75 per cent. of the above 50 per cent., or only 37½ per cent. of the *power*

employed, in consequence of the unavoidable losses arising from friction and practical imperfections.

The following supplementary calculations, illustrating the theory advanced in the Paper, were supplied by Mr. Stein respecting the results to be obtained from the experiment with Gwynne's Centrifugal Pump, that was described by Mr. Edwards, at the former meeting. In that experiment, recently made by Mr. Edwards with a Centrifugal Pump, containing some further improvements of his own invention, it was stated, that 650 gallons of water per minute were raised to a height of 17½ feet, by a revolving disc 13 inches diameter, and driven at 800 revolutions per minute: and the driving power was a high-pressure steam engine, with 8-inch cylinder and 18-inch stroke, working 100 double strokes per minute, with an effective pressure on the piston of about 43lbs. per inch.

The piston being 50¼ inches area (8 inches diameter), and moving at the velocity of 300 feet per minute (200 strokes of 1½ ft.),

The *power* expended on the piston of the engine was $\left.\right\} \dfrac{\overset{\text{sq. ins.}}{50\frac{1}{4}} \times \overset{\text{lbs.}}{43} \times \overset{\text{ft.}}{300}}{33{,}000} = 19{\cdot}6$ horse-power.

The *effect* obtained was $\dfrac{\overset{\text{gals.}}{650} \times \overset{\text{lbs.}}{10} \times \overset{\text{ft.}}{17\frac{1}{2}}}{33{,}000} = 3{\cdot}4$ horse-power.

Therefore the *useful effect* was 18 per cent. of the *power* expended.

According to the theory of the Centrifugal Pump in the Paper, "the *power* expended on the pump is measured by the quantity of water delivered, raised to *twice the height* due to the velocity of the circumference of the arms; whilst the *useful effect* produced is the water delivered, raised to the height of discharge." In the above case the velocity of the circumference of the arms was 2722 feet per minute, and the height due to that velocity (or the height of fall required to obtain that velocity by the action of gravity) is 32·3 feet, and twice the height is 64·6 feet, whilst the height of discharge was 17·5 feet.

Consequently the theoretical proportion of the *useful effect* to the *power* expended on the pump would be 17·5 to 64·6; and the *effect* obtained in the experiment as above being 3·4 horse-power, the *power* required to produce that amount of mechanical effect under these

circumstances (without considering the losses from friction and practical defects) would be $3{\cdot}4 \times \frac{64{\cdot}6}{17{\cdot}5} = 12{\cdot}6$ horse power, or in this case, a theoretical efficiency of 27 per cent.

The whole *power* employed having been 19·6 horse-power, this leaves 7 horse-power, or 35 per cent. of the whole, as the loss due to friction and practical defects, both in the engine and the pump.

The CHAIRMAN asked Mr. Appold to give the particulars of his Centrifugal Pump, and of the experiments that had been made with it.

Mr. APPOLD showed drawings of the Pump that he had shown at work in the Exhibition of 1851, and which had been experimented upon by the Jury at the Exhibition. The revolving fan A (see Figs. 1 and 2, Plate 68), is one foot diameter, and three inches wide, having an opening one-half the total diameter in the centre of each side, for the admission of the water, and a central division plate extending to the circumference, to give a direction to the two streams of water, and convenient for fixing on the shaft; the six arms are curved backwards, terminating nearly tangential to the circumference. The revolving fan is fixed on the end of the driving shaft B, passing through a stuffing-box in the side of the casing, and it works between two circular cheeks CC, running close without actually touching, which shields the outer revolving surfaces from the water, but allows a free ingress for the water to enter; and a large space, DD, is left all round the circumference of the fan, to facilitate the escape of the discharged water.

Mr. APPOLD stated that a series of experiments had been tried with his Pump at the Exhibition, to ascertain the percentage of useful effect that was yielded by it when raising water to different heights. These experiments were conducted by the Jury of the Exhibition, and the power employed in each

be proportioned to the work to be done, or it will not give a maximum effect.

In the Centrifugal Pump, the velocity of the circumference must be constant for all sizes of pump for the same height of lift; that is, a pump 1 inch diameter must make 12 times the number of revolutions per minute of one 12 inches diameter, and both pumps will then raise the water to the same height, but the quantity of water delivered will be 144 times greater in the 12-inch pump, being in proportion to the area of the discharging orifices at the circumference, or the square of the diameter, when the proportion of breadth was kept the same, namely, 1-4th of the diameter in each case.

Mr. Appold showed a small pump, of the same proportions, but only 1 inch diameter (the same actual size as the engraving in plate 68), with which similar experiments had been tried as with the 1 foot pump, and proportionate results were obtained.

This pump,	1 inch diam^r.	discharged	10	gall. per min.
And one	1 foot	,, ,,	1440	,, ,, ,,
Consequently,	10 feet	,, ,,	144000	,, ,, ,,

The height that the water was lifted being the same in each case, if the velocity of the circumference was the same.

A velocity of 500 feet per minute of the circumference raised the water 1 foot high, and maintained it at that level without discharging any; and a double velocity raised the water to four times the height, as the centrifugal force was proportionate to the square of the velocity; consequently

500	feet per min.	raised the water	1	foot	without discharge.
1000	,, ,,	,,	4	,,	,,
2000	,, ,,	,,	16	,,	,,
4000	,, ,,	,,	64	,,	,,

The greatest height to which the water had been raised, without discharge, in the experiments with the 1 foot pump, was 67·7 feet, with a velocity of 4153 feet per minute, being rather less than the calculated height, owing probably to leakage with the greater pressure.

A velocity of 1128 feet per minute raised the water 5½ feet without any discharge, and the maximum effect from the power employed in raising to the same height 5½ feet, was obtained at the velocity of 1678 feet per minute, giving a discharge of 1400 gallons per minute from the 1 foot pump. The additional velocity required to effect the discharge is 550 feet per minute; or the velocity required to effect a discharge of 1400 gallons per minute, through a one-foot pump, working at a dead level without any height of lift, is 550 feet per minute; consequently, adding this number in each case to the velocity given above at which no discharge takes place, the following velocities are obtained for the maximum effect to be produced in each case:—

1050 feet	per minute velocity,	for	1 foot	height	of lift.
1550	„	„	4	„	„
2550	„	„	16	„	„
4550	„	„	64	„	„

Or in general terms, the *velocity in feet per minute* for the circumference of the pump to be driven, to raise the water to a certain height, is equal to—

$$550 + (500 \sqrt{\text{height of lift in feet}}).$$

Mr. Benjamin Gibbons observed, that in the per-centage of effect obtained from a given power, he did not think the centrifugal pump could exceed an ordinary piston-pump of good construction, where a large quantity of water was to be lifted a small height.

Mr. Appold replied that he did not know a piston-pump that yielded so good a duty as 70 per cent., which might be taken as the effect obtained from his centrifugal pump, when working at the most effective velocity. The greatest result obtained in the experiments at the Exhibition, was 68 per cent., but some allowance had to be added in that case for the leakage through several large wood valves, 4 feet long, faced with leather, which were fixed in the suction-pipe of the pump, to pump the water from different levels.

Mr. B. Gibbons said he considered that a good plunger-pump would exceed 70 per cent. in duty.

Mr. Appold remarked that there were some situations where it was the most important consideration for a pump to be quickly and readily applied, that would discharge a very large quantity of water; and the centrifugal pump was found very advantageous in such cases, where the work could not probably be effected by other means. In one instance, in putting in the foundations of harbour works at Dover, a large quantity of water of 2000 to 3000 gallons per minute was pumped out by one of these pumps, which could not have been accomplished in the time by any other means, from the difficulty and delay of fixing ordinary pumps of that great capacity. The centrifugal pump had another important advantage for such applications from having no valves in action when at work, which enabled it to pass large stones, and almost anything that was not too large to enter between the arms.

The largest pump constructed at present on this plan, was erected at Whittlesea Mere, for the purpose of draining, and has worked there nearly a year with complete success. The pump is 4½ feet diameter, with an average velocity of 90 revolutions or 1250 feet per minute, and is driven by a double-cylinder steam engine, with steam 40 lbs. per inch, and vacuum 13½ lbs. per inch; it raises about 15,000 gallons of water per minute, an average height of 4 or 5 feet. The cost of the engine and pump was about £1,600. The following experiments were tried to ascertain the per-centage of effect obtained from the pump;—the power employed being measured by taking indicator-figures from the engine, deducting in each case the power that was indicated when the engine was working at the same speed without the pump, which was found to take 10·6 horse-power. The quantity of water discharged was measured by calculating the overflow from an opening, 6 feet wide in each case.

Experiments on Appold's Pump at Whittlesea Mere.

No. of Experiment	1	2	3	4
Velocity of Circumference of Pump, in feet, per minute.	1159	1357	1301	1329
Height of lift of the water, in feet and inches	3··0	4··1	5··0	5··11
Depth of water at point of overflow ... ... A	1··4	1··5½	1··8⅜	1··2
Ditto at 17 feet distance B	1··7	1··8¼	1··6⅜	1··5
Gallons discharged per min., according to the depth A	12429	14223	11706	9545
Ditto ditto ... ... B	16104	18023	15288	13606
Theoretical discharge	17400	21587	15768	12803
Horse-power effective in raising the quantity ... A	11·34	16·88	17·79	17·17
Ditto ditto ... ... B	14·70	22·38	23·24	24·49
Horse-power employed in working the Pump	23·00	40·90	29·90	39·80
Per-centage of effect to power employed, by calculation A	49	41	60	43
Ditto ditto ... ... B	64	55	78	61

The true result would be between these two calculations A and B, and the maximum effect might probably be taken at about 68 per cent. of the power; the same result as that obtained from the Exhibition experiments.

Mr. B. Gibbons observed that this Centrifugal Pump appeared a very ingenious machine, and very useful for some purposes; but the object was to obtain the plan which gives the greatest per-centage of duty, or the least waste of power. He was of opinion that for ordinary lifts, of say 10 to 30 feet, a bucket-pump of good construction performs more than 70 per cent. duty, and would be found consequently more economical in power than a centrifugal pump.

Mr. Appold said he found the Centrifugal Pump more advantageous for low lifts below 20 feet, than for higher lifts; but its most advantageous application was as a tidal pump, where the height of lift was continually varying, because it discharged more water the lower the lift, the pump still going at the same speed; but other pumps generally discharge only their cubic contents, no matter how low the lift. In one centrifugal pump, erecting at Shoreham, the height of lift will vary between 30 feet and nothing at different times of the tide.

Mr. Elwell inquired whether a centrifugal pump would be advantageous to be applied with a water-wheel, to assist in keeping the water-wheel at work, by returning a portion of the water, when the supply was short?

Mr. Appold replied, that one of these pumps had been applied for that purpose by Messrs. Curtis, at the Hounslow Powder Mills, to keep the water-wheel going constantly in the summer time, when short of water. The water was pumped up 7 feet high, by running the steam-engine a few hours extra at night, at a small expense, which completely kept up the supply for the water-wheel, and avoided bringing the engine any nearer the Powder Mills. The centrifugal pump was very convenient and economical for this purpose, and the result was found so satisfactory, that a second pump was going to be erected for a similar purpose.

The Chairman inquired whether Mr. Appold considered the spiral form of the arms an essential point in his pump, instead of the radial arms in the other centrifugal pumps?

Mr. Appold replied that the oblique position of the arms was most important, and the large amount of duty obtained from his pump was entirely owing to it; he had at first tried straight arms inclined at 45°, but he found that the curved arms ending nearly in a line with a tangent to the outer circumference, gave the greatest effect. The superior action of oblique arms to radial arms might be illustrated by supposing a vertical arm AB (see Fig 3, Plate 68) to move in a straight line to CD, in-

stead of moving round in a circle in the pump, and the body A, representing a particle of water, would then be simply moved along to C with the arm, without having any tendency to be propelled outwards along the arm to B. But if an oblique arm AE is employed, moving in the same direction as before to the position CB, it propels the particle A outwards towards B, having an inclined-plane action to push the particles of water outwards from the centre towards the circumference. When this was applied to a circular motion, and the direction AC bent into a circle, the inclined arm AE became curved in a spiral direction like the arms in the pump. The comparative value of the different forms of arms was proved by the experiments at the Exhibition mentioned before; the curved arms gave a duty of 68 per cent., the inclined arms 43 per cent., and the radial arms only 24 per cent.; and he understood that the two other centrifugal pumps of Mr. Gwynne and Mr. Bessemer, which were also experimented upon at the Exhibition, did not give a higher duty than 24 per cent., as they both had straight radial arms. The experiments would be all published in the report of the Jury. The facts quite bore out, therefore, the conclusions arrived at by the investigation in the paper that had been read, as to the effects to be obtained from centrifugal action with radial arms.

Mr. Clift observed that if there were no advantage in amount of duty in Mr. Appold's pump, there was certainly a great advantage in point of cost, and in convenience of application for many purposes. He proposed a vote of thanks to Mr. Appold for his attendance at the meeting, and the information he had afforded.

The vote of thanks was then passed.

The following paper, by Mr. George H. Bovill, of London, was read.

ON A NEW IMPROVED SCREW PROPELLER.

The Screw Propeller has now become so important a feature in steam navigation, that the writer has thought it a subject of

sufficient interest to induce him to bring under the consideration of the Members of the Institution of Mechanical Engineers, as well as the owners of screw vessels, some most important experiments made under his own directions upon a new propeller, invented and patented by Mr. Griffiths, which is in its form and general principles diametrically opposite to the screws adopted by the Government, and by all the Marine Engineers of the present day.

The screws generally used, as shown in Plate 70, are formed of two blades continued down to the shaft, the boss or centre being reduced to the smallest possible size consistent with strength. The Government, by their elaborate experiments with the "Rattler," "Minx," &c., appear to have determined thus far the general outline of principles for constructing the screw, but the correct pitch, diameter, and length, as well as the number of blades necessary for obtaining the best results, are still matters upon which scarcely two engineers agree, and the equally important point, the correct speed to drive the screws, is a still greater matter of doubt; and, notwithstanding the great labour and expense that have been bestowed on the subject by many engineers of eminence, to whom we are indebted for bringing the subject to its present state of practical utility, yet there appear no fixed and certain rules arrived at for constructing the screws and determining the speed at which they shall be driven to produce a given result. On reference to Mr. Murray's valuable work on Steam Vessels and the Screw, it will be found, on comparing the various vessels in her Majesty's Navy, that the most singular circumstances occur in the comparative proportions of screws, as well as the speeds *expected* from the engines, compared with the actual revolutions obtained on trial.

In the year 1849, Mr. Griffiths explained to the writer his then crude notions for removing the defects of the ordinary screw. The idea was so original, and appeared to him so correct, that he at once instituted a series of experiments, which proved to him the great importance of the invention, and induced him to make further experiments, which he believes will have removed the uncertainty and objections that surround the ordinary screw, thus rendering its future application and results as certain as the paddle-wheel.

The construction of the New Propeller is shown in Plate 71. Fig. 5 is an end view in a line with the shaft; Fig. 6 is a longitudinal section, and Fig. 7 a plan. Each of the propeller blades A A A is separate, and ends in a strong spindle B, which turns in a socket in the centre boss fixed on the propeller shaft C. A cross arm D is fixed in the spindle B, to turn round the blade and hold it in any required position, this arm working in a slot in the socket, and the end of the arm is connected by a pin to the block E, which slides in an oblique groove (shown in the plan, Fig. 7). This groove is formed in a ring F, which slides upon a feather, so as to revolve with the main shaft, and is moved by the bell-crank lever G, which is centred in the rudder post of the vessel, and is worked by a screw and handle upon deck, on the top of the rod H; by moving which the pitch of the propeller blades is easily altered to any required degree, and maintained in the same position, the strain being very small, as the blades are nearly balanced like a throttle-valve, having only a slight surplus of tendency to increase the pitch, or become more in line with the shaft. The whole of the apparatus is contained within the spherical casing I I, one-third the diameter of the propeller, which effectually protects it from injury.

It will be seen that the form of this Propeller is opposed to all the received notions of a correct Screw Propeller. The first leading feature is, that instead of continuing the blades down to the shaft, and keeping the centre boss as small as possible, one-third of the entire diameter is filled up as a sphere, as shown by the dotted circle in Figs. 1 and 2, Plate 70. In the experiments which Mr. Griffiths and the writer made, it was ascertained that the centre part of the blades of the ordinary screws, included within the dotted circle, *absorbed* 20 *per cent.* of the power, without having any propelling effect, in consequence of that part of the blades (particularly in coarse pitched screws) being nearly in a line with the shaft, the effect being when working to hurl the water off by its flapping and centrifugal action at right angles to the shaft, and seriously disturbing the more solid water upon which the more effective portion of the screw should act. The great vibration at the stern of all screw vessels arises from this flapping action of the flatter portion of the blades in their downward course, striking the

denser water below them, which, affording a greater resistance than the water above the blade in its upward course, produces this evil vibration, at an enormous sacrifice of power. The effect of this destructive action can be appreciated by the fact, that Screw Vessels if trimmed say two inches by the stern, when under canvas or at anchor, will suddenly be two inches down by the head the moment the engines are set to work; in point of fact, a large amount of engine power is exerted in lifting the stern of the ship out of the water, by the action of the flat part of the screw blades, as described.

The ball shown in the drawing is made to cover this destructive portion of the screw blades, or rather is substituted for the central third portion of the screw, as shown by the dotted circle in Figs. 1 and 2, Plate 70. It will be seen that the power required to revolve this in the water, at a great velocity, is insignificant compared with driving two or three comparatively flat blades of the same diameter, which may be fairly compared to the centre of a centrifugal pump. That there can be no tendency to vibrate the stern of the vessel is obvious, nor does the trim of the vessel alter in the least degree when under the action of the New Propeller. Moreover, from the water not being violently agitated by the centrifugal action, the effective parts of the propellers' blades are screwing in stiller and more solid water, producing a better result, and with a considerably less amount of slip. The water leaves the Propeller in a direct line with the vessel, and without the commotion resulting from the ordinary screw; the strength of the screw is much increased by this form, which also affords great facility for replacing the blades in case of accident, to which Screw Vessels in channel and river navigation are peculiarly liable.

The second important feature is the *form of the blades*, which instead of being larger at the extremities *are precisely the reverse*. The best form the writer has found to be as shown in the drawing, Plate 71, Fig. 1. The breadth of the blades is the full diameter of the sphere at the root, tapering to $\frac{2}{3}$ of this size at the periphery, at which part they are about $\frac{1}{4}$ only of the size of the ordinary screw blade; and with these proportions, so complete is the hold this Propeller has upon the water, that it has been requisite in practice

even to reduce the diameter considerably below the ordinary screw.

The water which follows the wake of the ship, and what the sailors call the "*dead water*," may be compared to the eddies below the piers of a bridge through which a rapid tide runs, and where, as every one knows, the water is *dead* or in a state of rest, the more so at the very centre of the pier. In a precisely similar condition is the dead water of a vessel, the water being most solid towards the centre, and gradually becoming less so until mixed in the current running beyond the width of the ship. It must be obvious that the nearer the work can be applied to the screw shaft the better mechanical result will be obtained; the arrangement of the blades of the new Propeller has been so contrived that their broad part is made at the ball, so that advantage is taken of the central dead water just described, to obtain the utmost duty from the propeller blade at its root or as near the screw shaft as the central ball will admit. The blades are reduced towards the periphery to meet the difference of velocity at which they travel through the water. So effective is the hold of these blades upon the water from the causes described, that the writer has found in practice the speed of the Propellers can be reduced, with the greatest advantage, one-third below the velocity found necessary for the ordinary screw, a fact which every engineer will admit to be of great value, seeing the many mechanical difficulties which present themselves in obtaining the speed hitherto considered necessary.

The screw has hitherto almost entirely been applied as *auxiliary power*, and where large power has been employed has never yet been made to equal the speed of the paddle-wheel. The imperfections of the screw appear hitherto to have placed a limit on the speed it was possible to obtain.

In those vessels where a large amount of engine power was applied, no adequate increase of speed was obtained, and in the case of the "Rifleman" and others, which were altered and the engine power absolutely reduced one half, as good a result was obtained after the alteration as with the larger power; showing that beyond a given power the water is *screwed through the*

screw, instead of the vessel being screwed through the water. This action takes place in all screw vessels to a most serious degree, when going head to wind, or in towing, when the engines make their full number of revolutions, but have little effect in propelling the ship. The perfect hold that the new Propeller has also under such circumstances upon the water, bids fair entirely to remove these difficulties, and will tend greatly to increase the value of the screw as a propeller.

The new Propeller was applied to a tug-boat, the "Lady Emily," 12 horse-power, diameter of screw, 3 feet 8 inches, on the Kennet and Avon Canal, under the direction of Captain Morrice, R.N., the manager; and the results showed that with one barge laden with 60 tons, she went from Bath to Bristol, deducting stoppages going through locks, in 2¾ hours, the distance being 18 miles. As other barges were added, the speed was reduced, and the engines were pulled up in exact proportion to the reduction of speed. The revolutions of the Propeller without any barge in tow, were 210 per minute; with a 60 tons loaded barge, they were reduced to 180; with two barges, to 160 revolutions per minute.

The question of the *pitch of the screw* appears hitherto to have baffled all those who have experimented upon it; the ordinary theory being that an increasing of the screw's pitch should either pull up the engines, or increase the speed of the vessel in proportion to such increase of pitch; but all the practice hitherto has proved this *not to be the case*, and, consequently, the screws have been made without any power of altering the pitch to meet the variations of winds and currents, to which all sea-going vessels are subject; and they have been thus deprived of what would appear to be the most valuable feature of the screw, viz., its power of adapting its pitch to meet every contingency. It has been found by the experiments that with the new Propeller the engineer can control the speed of his engines at pleasure, by increasing or diminishing the pitch of the blades, so that in a fair wind the full power of the engines may be exerted in effectually propelling the vessel, instead of consuming fuel in driving round the engines (with a fine pitched screw) to no purpose; and again, in going head to wind,

by diminishing the pitch the engines can be made to give out their utmost duty with a certainty of effectually propelling the vessel. The large central ball affords the opportunity of constructing a most simple and effective arrangement for altering the pitch of the blades, and feathering them parallel to the shaft when not required for propelling. The captain or engineer of the vessel can alter the pitch at pleasure without even stopping the engines, the speed of which is, by means of this apparatus, as completely under control as with a throttle valve.

A most serious disadvantage hitherto of the screw as a propeller, compared to the paddle-wheel, has been the great difficulty of going astern, and many serious accidents have happened to screw vessels in crowded navigations, from its being out of the power of the captains, when in difficulty, to go quickly astern; so soon as stern way is obtained, screw vessels will not steer, and become unmanageable. During the experiments in the "Ranger" with the new Propeller, the vessel was frequently stopped when at full speed, the engines reversed, and the ship brought quickly astern, nearly as quick as a paddle vessel, and a run was made above a mile astern, full speed, between Woolwich and Erith, steering among the various craft as easily as when going ahead. This fact gives further convincing proof of the complete power which this propeller gives the captain over his vessel. This power of going astern will be of enormous value to vessels of war in manœuvring in an engagement, which they do not now possess.

It will be clear by the accompanying Table of trials made upon the "Eagle," that as the pitch was increased, so was the engine brought up in her speed. The comparative slip between the new screw and the old one at same pitch, 7ft. 6in., is 272 yards per mile, or 13 per cent. with the former, against 665 yards, or 27 per cent., with the latter; the gain with the same pitch being an increased speed of $\frac{1}{4}$-mile per hour, with 27 revolutions per min. less of the engines, making 16 per cent. less consumption of power and coals. At the 9ft. 6in. pitch the increased speed is $\frac{5}{8}$ of a mile per hour, with 35 revolutions per min. less of engine, making a saving of 22 per cent. The table also contains trials of the "Ranger," 300 tons, in London, and the "Weaver," at Liverpool, the whole of the experiments illus-

trating the foregoing arguments. A sheer plan of the "Weaver" is given in Fig. 4, Plate 70.

Table of Comparative Trials of Griffith's Screw Propeller.

Trials of the	Description of Screw.	No. of Trial.	Screw Propeller. Diameter.	Screw Propeller. Pitch.	Screw Propeller. Extreme Angle.	Screw Propeller. Revolutions per min.	Engine. Revolutions per min.	Engine. Steam Pressure per in.	Engine. Vacuum pressure per inch.	Time of Running, the Measured Nautical Mile.	Speed. Statute Miles per hour. Boat.	Speed. Statute Miles per hour. Screw.	Slip of Screw.	Gain or Saving in Power.	Gain or Saving in Speed.
			ft. in.	ft. in.	Degrees.	No.	No.	lbs.	lbs.	min. sec.	Miles.	Miles.	per cent.	per cent.	per cent.
"Eagle" at Bristol.	Old	1	4 10	7 6	26½	200	200	38	—	5 34	12·36	17·00	27½	—	—
	New	2	4 10	6 6	23½	195	195	35	—	4 59	13·80	14·40	4	12¾	11¾
	,,	3	4 10	7 6	26½	173	173	37	—	5 23	12·79	14·74	13¼	16¼	3½
	,,	4	4 10	8 6	29½	171	171	34	—	5 25	12·70	16·51	23	16¾	2¾
	,,	5	4 10	9 6	32¼	165	165	35	—	5 15	13·12	17·80	26¼	22¼	6
"Ranger" at Liverpool.	Old	6	7 0	6 10	17¾	159	60	12	13½	7 3	9·76	12·33	20¾	—	—
	New	7	5 10	10 0	28½	116	44	10	12¼	6 36	10·45	13·23	21	36	6¾
	,,	8	6 2	6 8	19	143	54	12	12	5 8	13·45	—	—	—	—
	,,	9	6 2	6 8	19	132	50	—	—	11 14	6·14	—	—	—	—
	,,	10	6 2	6 8	19	137	52	12	12	8 11	9·80	10·42	6	—	—
"Weaver" at Long Reach	Old	11	3 3	4 6	24	332	83	11	14	6 2	11·40	16·97	32	—	—
	New	12	3 3	4 6	24	260	65	11	14	5 37	12·38	13·29	8	27	7½

EXPLANATION OF TABLE.

Trials of the Eagle at Bristol, June, 1851.

Single high-pressure Engine, cylinder 26 inches diameter, 18 inches stroke, screw worked by direct action. Vessel and Engine by Lunell & Co., Bristol.

No. 1 Trial—Average of several pair of runs with Common Propeller.

Nos. 2 to 5—Average of four pair of runs with New Propeller.

NOTE.—The New Propeller was made 4 feet 2 inches in diameter, but the opening in the vessel having been increased during construction to 5 feet, the Propeller was enlarged in diameter, by welding pieces on the points of the blades, which were thereby thrown out of their proportionate size.

Trials of the Ranger, at Long Reach, December, 1851.

Pair of Condensing Engines, cylinders 27 inches diameter, 24 inches stroke, screw worked by gear of 106 to 40. Vessel and Engines by Miller and Ravenhill.

No. 6 Trial—Single run with Common Propeller, with a 40 minutes ebb-tide, and wind in favour.

No. 7—Single run at top of tide, with New Propeller at the coarsest pitch.

NOTE.—The Ranger being employed on a station from which it was impossible to spare her for the purposes of experiment, there was no opportunity of making a proper set of trials to compare her ordinary screw with the new propeller; but her speed was taken at the measured mile, when going out with a cargo, with a 40 minutes ebb-tide and wind in her favour, as given in No. 6 trial.

No. 8—Run down with tide, with the New Propeller.

No. 9—Run up against tide, with the New Propeller, showing a reduction of 4 revolutions per minute of the Engine, with same pitch of screw.

No. 10—Average of Nos. 8 and 9 trials.

NOTE.—The pitch of the New Propeller was subsequently reduced to 5 feet 2 inch when running against tide, which allowed the Engines to get up to 70 revolutions per minute, by which a speed of 7·95 statute miles per hour against tide was obtained, and this added to the run down with tide No. 8 at 6 feet 8 inch pitch, gives an average speed of 10·69 miles per hour.

Trials of the Weaver at Liverpool, June, 1852.

Pair of Condensing Engines, cylinders 22 inches diameter, 15 inches stroke, screw worked by gear of 4 to 1. Vessel by John Laird, Birkenhead, Engines by Fawcett Preston & Co.

No. 11 Trial—Average of pair of runs with Common Propeller, from Woodside-pier to Eastham-pier, 5¾ statute miles.

No. 12—Average of pair of runs, between the same places; with same state of tide as No. 11 trial, in the preceding week, but wind strong and unfavourable, and a heavy sea.

A model, illustrating the principle of the New Propeller, was exhibited by the Secretary (Mr. Bovill having been prevented from attending the meeting). The model showed an ordinary screw propeller, which was divided into three portions, like the drawing in Plate 70, so that one-third of the propeller in the centre could be removed, and a ball of the same diameter substituted, upon which the two blades forming the remainder of the propeller were then fixed, in the same relative position as in the original propeller.

Mr. Preston said he had witnessed the experiments made on the "Weaver," that were described in the Paper, and could confirm the statement made as to the superiority of the New Propeller in the diminution of slip, and the increase of speed of the vessel. He did not perceive any superiority in the amount of back-water produced; in going a-head the vessel dipped a-stern with both propellers, and he did not perceive any difference; but it was a very flat vessel, and the bows rose so abruptly that the head was forced up by the action of the water. The experiments were tried in the Mersey, above Liverpool, and the effect of tide was deducted by trying the experiment both ways. He doubted the practicability of keeping the apparatus for altering the pitch in working order, at sea, for any length of time.

Mr. Ramsbottom remarked, that if the pitch of the blades in an ordinary screw-propeller were the same throughout down to the centre boss, every part of the blade would have the same advancing motion in the water, and would screw correctly through it; and he could not understand how the centre portion of the blades could have the injurious flapping and centrifugal action mentioned in the Paper, when the screw was advancing through the water, as such action could only take place if the arms were to revolve whilst the vessel was stationary.

Mr. Appold observed, that the ball would deflect the water, and throw a body of water on to the blades, giving them more water to act upon, and preventing the water from slipping away

from the pressure of the blades, through the centre of the propeller, as in the ordinary form with an open centre. Supposing the propeller were working through a tube of the same diameter as the circumference of the arms, the centre ball would occupy one-third of the diameter of the tube, and reduce its effective diameter, causing all the water to pass through the reduced area, and so bringing more water in contact with the arms in the same distance, and affording them a more solid abutment for their action.

Mr. B. Gibbons thought it was to be inferred from that argument, that it would be advantageous to enlarge the shaft to the size of the ball, so as to fill up the displacement of the ball, and that would avoid the resistance offered by the front of the ball being dragged through the water.

Mr. Appold suggested that a conical form might be preferable for the front of the ball, to deflect the water from the centre on to the arms. He had found that best in his Centrifugal Pump, in which there was a similar action, and the water entering at the centre had to be suddenly deflected at right angles into a radial direction; he had tried a pump with the centre bell-mouthed from the inside, with the object of affording a more free entrance for the water, but he found it gave less results than the form he had adopted, having a square edge inside the opening, and the centre coned from the spindle to the centre disc.

The Chairman observed, that further experiments with the New Propeller were very desirable; and he proposed a vote of thanks to Mr. Bovill for his Paper, with a request that he would furnish to the Institution the results of further trials of the Propeller, which was passed.

The following Paper, by Mr. W. Keld Whytehead, of London, was then read:—

ON A NEW DIRECT-ACTING STEAM PUMP.

This Steam Pump is of American invention, and has been used extensively there for feeding the boilers of marine engines. It is, however, well adapted for any purpose, where a moderate quantity of water has to be raised, and where a rotary motion is not required. The drawing Plate 72 shows one that is fixed at the Great Northern Railway Station, at King's Cross, London, and used for supplying the station with water.

Its chief peculiarity is that the stroke of the piston and of the pump plunger is regulated without the use of a crank, so that the motion of the plunger is nearly uniform for the whole length of the stroke. Mr. Ericsson (of Messrs. Braithwaite's firm,) made a fire-engine on this principle, some years back, and Mr. Penn formerly used the same arrangement for "donkey engines" for steam-boats, but both of these kinds of engine were deficient in smoothness of working, a difficulty which has been overcome by Messrs. Worthington and Baker, the patentees of the present Pump, by very simple and effectual means.

Fig. 1, Plate 72, is a longitudinal section, and Fig. 2, a transverse section of the Pump. A is the steam piston, and B the pump-plunger, both bolted to the same piston rod. The plunger is double-acting, and works through metallic packing CC. D D are the suction valves, and E E the delivery valves, consisting each of a ring of India-rubber, rising on a brass spindle, with a guard at the top, and falling on to a circular plate, perforated with holes, as shown in the enlarged drawing, Fig. 3. In the plunger are bored a few holes HH, which have the effect of opening a communication between the two ends of the pump barrel at each end of the stroke, thus giving the water, as it were, a partial elasticity, allowing it to continue its forward motion, by flowing through the plunger during the moment that the plunger becomes stationary. This enables the plunger to commence its return stroke without any shock or concussion.

The slide valve I is moved by the tappet K, fixed on the piston rod, and striking either of the nuts L or M. Steam is admitted *under* the slide, as shown, as the motion of the slide in one direction has to admit steam for the piston moving in the opposite direction. A "steam buffer" is provided for the slide, to remove the concussion;

N is a piston attached to the slide rod, working in a cylinder, which has a small groove cut in the bottom of it. This cylinder is filled with steam from the slide chest, through a small hole in the end, and the steam is compressed by the piston N, at each stroke of the tappet K, thus forming a buffer or spring of very perfect elasticity, and the compressed steam escapes immediately afterwards to the other side of the piston N, through the groove in the bottom side of the cylinder, thus preventing any recoil of the valve. O is an air-vessel on the delivery pipe, and the suction pipe P is carried up above the pump to form a head, to make the flow of water more uniform. In starting the Pump, the hand-lever R is put into gear with the nut L, as shown by the dotted lines, and the valve is moved by hand for a few strokes, to let on the steam, until the engine is fairly started.

This Pump has been at work for five months at King's Cross Station very satisfactorily, the only repairs necessary having been about one day's work. It has to draw the water 14 feet perpendicular, and forces it 30 feet perpendicular. The usual speed is 40 to 50 double strokes per minute, but there is no difficulty in working it double that speed if desired. The uniformity of the stream of water delivered is very remarkable, and seems to indicate that there is no loss of power, or to speak more correctly, that there is never an excess of power to impart an undue velocity to the water. The small space occupied by the pump is an advantage of some importance when used for marine purposes.

Mr. Ramsbottom observed that he had seen the pump at work at the King's Cross Station, and it certainly worked well, with very little vibration, and delivered a steady uniform stream of water; but it was a defect that the economy of working expansively could not be obtained with a pump on that principle, as the full pressure of steam was required to complete the stroke. There was a simple contrivance in the shut-off valve of the delivery pipe, for changing the direction of the discharge; the valve was constructed with a double face, and

fitted to shut the opening on either side, so as to pump into the tank, or into the fire-hose, by screwing the valve spindle in one direction or the other.

The SECRETARY said that Mr. Whytehead had expected to have given the results of a trial of the pump to ascertain the duty yielded by it, by measuring the quantity of water discharged, and taking indicator figures from the engine; but he had not yet been able to make the experiments.

Mr. PRESTON remarked, that a direct-acting steam pump had been constructed by Mr. Penn, for feeding marine boilers, but that he adopted a crank motion now for the purpose, finding the vibration and shock of the tappet motion too great for working the valve.

Mr. RAMSBOTTOM observed that the steam buffer-spring upon the valve spindle in this pump appeared to be very effectual in taking off the shock, even when working at a considerable speed; and the equilibrium established between the two ends of the pump, by means of the holes through the plunger, caused the valves to close down upon their seats almost before the return stroke, and prepare the pump for the reversed action of the steam.

Mr. MIDDLETON thought there would not be any advantage gained with this pump in simplicity over a crank engine, and it would not be so economical in power, from not being able to work the steam expansively.

Mr. APPOLD inquired how long the India-rubber valves were found to last in pumps?

Mr. PRESTON said the India-rubber valves answered very well in the air-pumps of marine engines; they were always used for screw vessels, on account of the rapid action of the valves with short-stroke engines, for which metal valves were not applicable. The time they lasted varied very much with the circumstances; vulcanised sheet India-rubber only should be used, and might last some months, perhaps a year, but the canvas valves coated with India-rubber soon decayed.

Mr. CLIFT remarked that a new mode had been brought out of preparing India-rubber with sulphuret of lead, instead of vulcanising it with sulphur, which was said to be better and more durable; but he did not know the results of trial.

Mr. APPOLD doubted whether vulcanised India-rubber would stand a constant elastic action for a year, or even a less period. He had tried some India-rubber springs for window-shutters, and found they failed in three or four months; it was some years back, and he did not know whether the process of manufacture had been improved since.

Mr. B. GIBBONS said he had found the elastic bands for papers, after lying by for two or three years, lost their elasticity, and became decayed.

Mr. ADAMS inquired whether the vulcanised India-rubber rings in railway carriage buffers and draw-springs were found to decay?

Mr. H. WRIGHT said he had found the rings in buffers still remaining good after three or four years' work; the India-rubber was subjected to compression only, and was protected from wet. He had several hundred waggons under his charge working with India-rubber buffers and draw-springs, which were all doing very well; the only failure of the India-rubber rings that had been experienced amongst them, was from the intermediate plates or washers between the rings, which were made at first of cast-iron, and too thin, becoming broken and then cutting the India-rubber, but that had been remedied by using stronger wrought-iron washers.

Mr. S. LLOYD observed, that the India-rubber buffers had also been several years in extensive use on the Great Western Railway for all their carriages, and he believed with satisfactory results.

Mr. CLIFT remarked that it had been explained by the maker, Mr. De Bergue, at a former meeting of the Institution, that there was some imperfection in the vulcanised India-rubber first manufactured, which made it less durable, but the defect was removed in all the subsequent manufacture.

Mr. Preston observed that the India-rubber in pump valves was subjected to more severe wear, from the constant rapid bending, and the action of the water, than the mere compression in buffer springs. Some of the valves proved defective at first in consequence of being cut transversely from a cylinder of India-rubber, which was manufactured by rolling up a long sheet; these valves split open in the roll and became defective, from the constant action upon them; but all he now used were cut out of a single flat sheet, and were found to stand very well.

The Chairman proposed a vote of thanks to Mr. Whytehead for his description of the pump, which was passed, and expressed a hope that he would furnish at another meeting the results of a trial of the duty yielded by the pump.

The following paper by Mr. John E. Clift, of Birmingham, was then read:—

ON IMPROVED FIRE-BRICK GAS RETORTS.

The object of this paper is to describe a plan for constructing Gas Retorts, which the writer has had in use several years at the works under his management, and has also adopted at various other towns; and the only apology he has to offer for bringing it before the meeting is, the request of the Council of the Institution to furnish the practical results of the working of the plan.

The first great desideratum in a gas-generating retort is on all hands acknowledged to be *surface*, a large surface, upon which may be spread a thin layer of coal; this was early shown by Mr. Clegg, in his invention of the revolving-web retort, the only difficulty in working which was the destructible nature of the material of which it was composed.

The second condition required is, that this large surface shall be *economically heated*. A strong opinion existed for a long time against the use of fire-clay for retorts, in consequence of the inferior heat-conducting properties of that material compared with iron; but experience has proved that as large a quantity of gas can be generated, with a given weight of fuel, with fire-clay retorts as with iron.

This may be accounted for partly by the fire-clay losing less of its heat on being exposed to the air whilst charging, and on the cold charge of coal being first thrown in; or in other words, that the greater mass of fire-clay acts as a reservoir of heat, and does not become so readily exhausted when a large demand is made upon it, but on the contrary maintains a greater uniformity of temperature throughout the process; this is easily demonstrated by observing the small quantity of gas made from an iron retort during the first hour after charging compared with a fire-clay one. It is also partly accounted for by the iron retorts, as they are generally set, being so covered and shielded with fire-bricks to preserve them from destruction, as to partake as much of the character of clay retorts as of iron.

The following table, which is the average of a number of experiments, gives the quantities of gas generated, as indicated by the meter, from iron and clay retorts, during each half-hour of the charge, from the same quantity and quality of coal:—

IRON RETORTS.				BRICK RETORTS.			
1 half-hour.		250	Cubic feet.	1 half-hour.		480	Cubic feet.
2	,,	630	,,	2	,,	1800	,,
3	,,	1340	,,	3	,,	2000	,,
4	,,	2300	,,	4	,,	2000	,,
5	,,	2600	,,	5	,,	2300	,,
6	,,	2640	,,	6	,,	2300	,,
7	,,	2600	,,	7	,,	2460	,,
8	,,	2600	,,	8	,,	2400	,,
9	,,	1700	,,	9	,,	2000	,,
10	,,	1630	,,	10	,,	1630	,,
11	,,	1790	,,	11	,,	860	,,
12	,,	700	,,	12	,,	550	,,
	Total	20780			Total	20780	

The third requisite in a retort is *durability*. The proper way to measure this element is to divide the quantity of gas made, by the cost of the retorts and ovens, and the repairs during the time they are worked; this will be shown presently by a comparison from the actual working of iron and clay retorts.

The retorts to be described in the present paper are composed entirely of fire-bricks, with cast-iron front plates to attach the mouth-pieces to, and to bind the brickwork together, and they are made of any length, width, or height. They are generally constructed in sets of three, as shown in Fig. 1, Plate 73, which is a front elevation. A A are the front plates of cast iron, 1½ inch thick. B B are the wrought iron stays, 4 × 1½ inches, fastened at the bottom by cramps built into the brickwork, and at the top by tension bars, connected to similar stays on the opposite side. C is the furnace door. D D, two retort mouth-pieces, 15 × 15 inches. E, a large retort mouth-piece. F, sight holes for examining the flues and cleaning dust from the external surface of the retorts.

Fig. 2 is a transverse section; G is the furnace, H H are the two lower retorts, 15 inches wide, 15 inches high, and 20 feet long, with a mouth-piece at each end. The fire-bricks forming the bottoms and sides of the retort are 16 inches long and 3 inches thick, and the arch-bricks forming the top are 9 inches long by 3½ inches deep. Each brick is rebated 1 inch deep in the transverse joints, and grooved in the longitudinal joints, as shown by the enlarged drawing, Fig. 3; these grooves are filled with stiff fire-clay when they are put together, which burns into a hard tongue half an inch thick as it becomes heated; the object of these tongues is two-fold,—they offer a resistance to the leakage of the gas by breaking the joint, and they tie together the arch of the retort.

K is the large upper retort, 5 feet 3 inches wide, and 20 feet long, open for charging at both ends; the bricks are similar to those forming the small lower retorts; L is a cross arch 5 inches thick, spanning the furnace flat on the top, which covers the underside of the transverse joints of the bottom of the large retort; the longitudinal joints are covered by small arched bricks, marked I. J are the side flues, and N the longitudinal flues, shown more fully in Fig. 4, Plate 74, which is a plan of the top of the upper retort, showing the course of these flues. In rising from the furnace the heat passes partly underneath and partly over the small retorts into the first flue, No. 1, moving to the back of the oven, then crosses the division and returns to the front along the 2nd flue, then to the

back along the 3rd flue, and to the front along the 4th, when it meets with the heat which has gone through a similar course on the opposite side, and passes along the middle flue, No. 5, into the main flue M, as shown in the longitudinal section, Fig. 5. By this arrangement the heat passes over 50 feet length of surface of retort from the time it leaves the furnace until it reaches the main flue.

Fig. 5 is a longitudinal section through the upper retort K, showing the opening into the main flue M, and the damper O, by which the draught is regulated. In this figure the position of the cross arches L, that carry the large retort is shown, covering the joints in the bottom of the retort; also the centre wall P, which divides the two furnaces and flues, and carries the main flue.

Fig. 6, Plate 75, is a plan of the lower retorts, showing the two furnaces GG, with the centre division wall P, the side flues I I, and the floor of the lower retorts H H.

It will be seen by the plans Figs. 4 and 6, that the sight holes F F are so arranged as to command a view of the whole longitudinal and side flues, by which means the condition of the retorts may at all times be observed, and any defects detected.

With regard to the durability, the writer may observe that 12 sets of these retorts were put up by him in 1842, and worked constantly, with the exception of short periods, up to 1849, when they were taken down for the alteration of the works, and they were found then in good condition, and were fit for working several years longer with slight repairs. The writer also put up 12 sets of these retorts in 1844, and they continue in regular work now, and are in good condition; the cost of repairs of the retorts, ovens, and furnaces during the eight years they have worked has not exceeded 20 shillings per annum for each set.

The writer accounts for the durability and economy of retorts constructed on this plan, firstly, by their being composed of a great number of pieces, instead of only one; so that when their temperature is altered, either by the carelessness of the stokers, or in letting down the heat to throw the retort out of work, each joint opens a little, equal to the contraction of a 9-inch brick, and prevents any portion of the retort cracking. In the same way, in getting up the

heat (which is a time when a great number of clay retorts made in one piece are destroyed), if one portion of the retort becomes heated more than another, the joints accommodate the expansion; or, if the brick-work is in a very green state, and the expansion from the moisture is great, the screws of the tension rods may be eased, which will allow the whole mass of brick-work to swell, but as soon as the moisture is expelled it will sink back into its place, and be as perfect as when first built. When a set of these retorts is first put to work, either new or after being let down for any purpose, it leaks through the joints for about 24 hours, gradually stopping, and after that time, if the heat be good, it will have become quite sound, and permanently gas-tight, under a pressure equal to 10 or 12 inches head of water.

From a sufficiently long experience, the writer has proved that brick retorts built upon this plan will wear for 10 years, with the outlay of twenty shillings per annum for repairs, and that iron retorts will not last more than 1½ years, under the most favourable circumstances. Then, to show their comparative economy, take a number, say 20 sets or beds of Iron Retorts, and 20 beds of Brick Retorts, each bed being capable of making 20,000 cubic feet of gas in 24 hours, and to make the calculations as correct as possible, let the cost and repairs of each be estimated, and the quantity of gas they will make, during a period of 10 years, in order to ascertain the cost of the gas produced from each plan per 10,000 cubic feet.

First cost of 20 beds of Iron Retorts:—

	£.	s.	d.	£.	s.	d.
Bricks, clay, and labour for arches... ...				367	0	0
100 Cast-Iron Retorts, 18 cwt. each, 90 tons, @ £6...				540	0	0
Fire bricks, shields, quarries, &c., for setting				150	0	0
Labour for setting, 60s. each				60	0	0
Carried forward				£1117	0	0

		£	s.	d.	£	s.	d.
Brought forward					1117	0	0
Cost of renewing 20 beds of iron retorts :—							
100 iron retorts, 90 tons, @ £6		540	0	0			
Bricks and clay...		150	0	0			
Labour, taking down and resetting... ...		80	0	0			
		£770	0	0			
Less by old burnt iron, 50 tons, @ 25s.	£62 10 0						
Less by one-third of bricks, which may be used again	50 0 0						
		112	10	0			
		657	10	0			
This sum will be multiplied by 6½, the number of times they will be renewed in 10 years, which will give...					4270	10	0
Making the total expense of Iron Retorts					£5387	10	0

	£	s.	d.	£	s.	d.
First cost of 20 beds of Brick Retorts :—						
Bricks, clay, and labour, for arches ...				367	0	0
Iron for front plates and brick-stays, 21 tons, @ £6...				126	0	0
Pattern and other bricks and clay for retorts				180	0	0
Labour for building retorts				110	0	0
				783	0	0
Cost of repairs for 10 years, at 20s. per bed per annum...	100	0	0			
Less value of old front plates, &c., 20 tons, @ 25s.	25	0	0			
				75	0	0
Making the total expense of Brick Retorts				£858	0	0

Now, as the quantity of gas that each of the two descriptions of retorts is estimated to generate is the same for 10 years, namely, 1460 millions cubic feet, it follows that the gas from the Cast-Iron Retorts costs 9d. per 10,000 cubic feet, and that from the Fire-Brick Retorts 1½d. per 10,000 cubic feet, for the item of retorts and ovens; showing an economy of 84 per cent. in the improved Fire-Brick Retorts.

Mr. Clift exhibited specimens of the Fire-bricks, showing the mode of jointing them to prevent leakage of the gas.

Mr. Chellingworth enquired whether a defect in a brick retort could be repaired, such as a bad joint? When an iron retort became broken it could not be repaired, and was all lost, and had to be pulled out, but it was a great advantage in the brick retorts if they could be readily repaired.

Mr. Clift replied that a defect could be easily repaired at any time, without stopping the working of the retorts; the surface of the retorts could be thoroughly examined through the different sight holes, and any defective joint detected by the appearance of a gas flame, and a single brick could be taken out of any part when required, and removed by proper tools through the sight holes, which were made large enough for a brick to pass, and another brick was then set in its place with fire-clay, without occasion to let down the heat of the retort. When a brick retort was pulled down, it was found that the carbon deposited from the gas filled up any crack or fracture, by the carbon adhering to the rough surface of the brick and collecting upon it, from the indestructible nature of the brick. But a crack in a cast-iron retort continued getting worse, and became constantly more open, on account of the surface of the iron perishing in the sides of the crack, which prevented it from getting closed up by a deposit of carbon as in the brick retorts. When a cast-iron retort was once cracked it was done for, and must be thrown away, requiring the whole oven to be opened out and re-built, and causing a serious delay to the work, as well as expense.

Mr. RAMSBOTTOM remarked that the greater equality in the rate of expansion by heat of carbon and fire-brick, than of carbon and cast-iron, would probably assist in keeping the joints close.

Mr. CLIFT observed, that on pulling down the brick retorts, after seven years' working, it was found that the joints were completely blackened and filled with carbon half way through, up to the fire-clay stopping in the centre groove, but the outer half of the joints showed no appearance of the carbon having passed the groove.

Mr. H. WRIGHT said he had lately had some gas ovens built on Mr. Clift's plan, instead of renewing the cast-iron retorts used previously, and they had been at work for some months very satisfactorily; there was no appearance of defect in getting up the heat or letting it down, and he considered that the plan was an important improvement.

Mr. CLIFT observed that the plan of constructing the retorts of double the usual length, with a mouth-piece at each end, he had only had in use for about a year, but he found it a decided improvement, and had since adopted it all in new works. The other retorts became scurfed up with a large accumulation of carbon, particularly at the back ends, where the scurf became several inches thick and very hard, and the retorts had to be stopped work and the heat let down, usually every eight months, for the purpose of clearing out this scurf, and getting it detached by the contraction in cooling. But in the long retorts, open at both ends, there was no back for the scurf to accumulate, and the current of air through the retort every time that both ends were opened, caused the scurf to scale off, and it was much easier to detach, and consequently it was found that they would work much longer before requiring to be let down. Also the centre portion of the oven, which is the hottest part, and most valuable for making gas, was lost before by the blank ends of the retorts, but is now made available, as there is only a single brick wall dividing the flues, and by this means the heating

surface and contents of the retorts are increased, without any increase in the size or expense. Another advantage is found in preventing the injury and shaking of the joints that was caused in drawing the coke from the retort, by the heavy rake being driven against the back of the retort.

The thanks of the meeting were voted to Mr. Clift for his Paper, and the meeting then terminated.

After the meeting a Model was exhibited of a new construction of Permanent Way for Railways, by Mr. J. E. McConnell, of Wolverton.

INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

HELD IN BIRMINGHAM, ON 27TH OCTOBER, 1852.

ROBERT STEPHENSON, ESQ., M.P., PRESIDENT

IN THE CHAIR.

BIRMINGHAM:

PRINTED AT M. BILLING'S STEAM-PRESS OFFICES,

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1852.

PROCEEDINGS.

The General Meeting of the Members was held at the house of the Institution, 54, Newhall Street, Birmingham, on Wednesday, 27th October, 1852, Robert Stephenson, Esq., M.P., President, in the Chair.

The Minutes of the last General Meeting were read and confirmed.

The Chairman announced that, according to the rules of the Institution, the President, Vice-Presidents, and five of the Council in rotation, would go out of office next year; and that at the present Meeting the Council and Officers for the next year were to be nominated for the election at the next Annual Meeting. He observed, that he had always held that in such Institutions as their own, it was highly conducive to their advancement that the officers be changed periodically, especially the President. He had taken an active part in bringing about the change in the Institution of Civil Engineers of the injurious system of Life Presidents, and since that change he had every reason to believe the result was very satisfactory. He had proposed to the Council to retire at this next election, having been President for four years, since the decease of his Father; but as the Council had expressed a desire that he should be put in nomination for one year longer, he had consented, on the understanding that the proposed alteration should be then carried out, making the President ineligible for re-election after one or two years.

The Chairman announced that the Council proposed to submit to the Members, for decision at the next Annual Meeting in January, an increase in the number of Vice-Presidents from three to six, with reference to the different Meetings of the Institution in Birmingham, and other places.

Nine names were proposed for nomination as Vice-Presidents, and if the proposed increase was adopted at the Annual Meeting, the six highest would be elected, otherwise the three highest as before.

The following list of Members was then proposed for nomination for the election of the Council and Officers at the next Annual Meeting.

President:

* ROBERT STEPHENSON, M.P., London.

Vice-Presidents:

(Six or three of the number to be elected.)

* CHARLES BEYER, Manchester,
WILLIAM FAIRBAIRN, Manchester,
EDWARD HUMPHRYS, London,
EDWARD JONES, Liverpool,
* JAMES E. McCONNELL, Wolverton,
* JOHN PENN, London,
R. B. PRESTON, Liverpool,
ARCHIBALD SLATE, Dudley.

Council:

(Five of the number to be elected.)

SAMUEL H. BLACKWELL, Dudley,
* WILLIAM BUCKLE, London,
* JOHN E. CLIFT, Birmingham,
BENJAMIN FOTHERGILL, Manchester,
WYNDHAM HARDING, London,
JOHN NAPIER, Glasgow,
RICHARD PEACOCK, Manchester,
* J. SCOTT RUSSELL, London,
* ROBERT SINCLAIR, Glasgow,
* JOSEPH WHITWORTH, Manchester.

Treasurer:

* CHARLES GEACH, M.P., Birmingham.

Secretary:

* WILLIAM P. MARSHALL, Birmingham.

(The Officers for the present year are marked thus.)*

No other names having been added by the Meeting, the above list was adopted.

The CHAIRMAN announced that the Ballot Papers had been opened by the Committee appointed for the purpose, and the following new Members were duly elected:—

Members:

SAMUEL LLOYD, jun., Wednesbury,
HENRY ROFE, Birmingham,
GEORGE THOMSON, Birmingham,
JOHN R. WARHAM, Burton-on-Trent.

The following paper, by Mr. SAMUEL H. BLACKWELL, of Dudley, was then read:—

ON THE ARRANGEMENT OF THE MATERIALS IN THE BLAST FURNACE, AND THE APPLICATION OF THE WASTE GASES.

The use of the Waste Gases given off from the top of the Blast Furnace, has been long known and adopted in many of the Continental Iron works. The higher cost of fuel, and the greater attention paid to a scientific knowledge of the most important processes of manufacture, led to the use of the waste gases of the Blast Furnace in the works of France and Germany, long before their application here; the United States soon followed the example of the Continent, and in the iron works of Pennsylvania, for some years past, the use of the waste gases has been general. The object of this paper is to point out some of the causes which have prevented their more general use in England in our great iron works, and to call attention to some light thrown, by the attempts to use them, upon the best arrangement of the materials in the furnace.

The first attempt to apply the gases in our iron works was at Ystal-y-Fera, in South Wales, where a patent for their use was taken out by Mr. Budd. The method of employing them

was at first defective, from the direct flame of the furnace being taken off, instead of the gases themselves. The moment the gases emerge from the top of the furnace, and unite with the atmosphere, ignition takes place; and if the flame is to be economised, it must be immediately applied to the surface upon which it is to act, or its heating power is given off, and consequently wasted. The attempt therefore to apply *flame*, necessitated the erection of the boilers, or of the pipes in which the blast was to be heated, in immediate contiguity with the tunnel head. In many works this was a matter of great difficulty, and in very few could it be done without inconvenience. Even where practicable, the flame always acted powerfully upon the passages through which it passed, and exhausted itself in proportion to their length and absorbing powers, before it became available at the points where it was really required. This difficulty led to such an alteration in the arrangements adopted, that instead of the *flame*, the *gases* themselves could be drawn off the materials in the furnace, before they had become ignited by mixing with air. This was effected by the arrangement shown in Fig. 1, Plate 76. A cylinder A, of cast or wrought iron, resting by a broad flange upon the lining of the furnace, was carried down to a depth of several feet beneath the top of the pipe B, through which the gases passed off. The diameter of the furnace expanding from the top downwards, an open space CC, was thus enclosed between the inside wall of the furnace and the cylinder, forming a reservoir for the gas, into which, as long as the cylinder was kept full, no air from above could enter.

This arrangement perfectly answered its purpose, as far as taking off the gases unignited; and although they still passed off at a high temperature, the loss of heat in the passages was much diminished, being confined to simple radiation from the hot but unignited gas: however far it was carried its chemical nature remained unchanged, and atmospheric air was allowed to mix with it only on its reaching the point were the heat given off in its combustion became available.

All difficulty in placing either the pipes for heating the blast or the boilers was thus obviated, but there remained two sources of inconvenience. First, a very powerful draught was required to be given by a sufficient height of stack to draw off the gases with regularity; and second, the entire quantity which it was possible to

draw off under the most favourable circumstances, bore only a small proportion to the entire quantity generated in the furnace, the greater part of which still escaped through the open cylinder.

Where a powerful stack was at hand, and where it was not a matter of importance to economise the entire amount of gas generated, this arrangement was in many instances satisfactory. It was not, however, always so; in many works it was found impossible to get the furnaces to work well after the gases were taken off; great fretting of the twyeres, accompanied by frequent scaffolding and slipping in the furnace, was constantly producing irregularity in its working; the quantity made would thus be much decreased, and, after much annoyance, the attempt to use the gases was in such cases generally abandoned, as productive of more inconvenience and loss than economy.

This was much more the case in South Staffordshire than in Wales. In the former district it led, after three or four trials, all with the same result, to its complete abandonment. It was difficult to understand the cause of this great irregularity in the results obtained, which at first seemed inexplicable; but this cause is now believed to be fully understood.

In the year 1849, two furnaces in Derbyshire were placed in the writer's hands, from which the gases were taken off for the purposes of heating the blast. The furnaces worked with considerable regularity whenever the heat could be properly maintained, but this was not constantly the case, in consequence of the opening into the gas flues being situated so near the top of the furnace that, when the wind was in certain directions, the gas did not pass off with regularity, or if it came off in sufficient quantity, it was so mixed with atmospheric air that it burned down the passages, and thus occasioned great inconvenience.

The writer determined upon obviating this by covering the opening into the gas flue with a wrought-iron cylinder, as in Fig, 1. The tops of the furnaces were small, and only admitted of cylinders of the respective sizes of 4½ feet and 6 feet being employed. This effect was perfectly satisfactory, in enabling a regular supply of unignited gas to be obtained; but the furnace with the 4½-feet cylinder began to scaffold and slip; the twyeres were exceedingly

troublesome, and the weekly make fell off considerably. After a trial of one or two weeks, the cylinder was taken out, other means were adopted to prevent the gas taken off from becoming ignited, and the furnace again resumed its former regularity. The furnace into which the 6-feet cylinder had been placed, worked far better, but not quite satisfactorily, and upon the cylinder burning out, it was not replaced, arrangements being made similar to those adopted in the other furnace. It will not be necessary to describe the exact details of these arrangements, as arrangements similar in principle, but improved by subsequent experience, will be afterwards described; they did not differ much from those shown in Fig. 6, Plate 78. Both furnaces have worked ever since satisfactorily, and the gases taken off furnish all the heat required for heating the blast; no slack whatever having been used for some years for the purpose.

It was evident from this trial, and from similar results at other works, that the irregularity did not arise from the mere abstraction of the gases themselves; and there was only one other cause to which it could be attributed, viz., the narrowing of the filling part of the furnace; and the question then arose, in what way did this operate? The first suggestion that presented itself was naturally that the effect produced arose from decreasing the area through which the gases generated in the furnace were given off, and thus causing greater obstruction to the free passage of the blast.

This explanation was soon found to be untenable.

The saving effected in some of the Welsh works by the use of such portion of the gases as could be economised by the use of the cylinders employed there, led to a wish to make the entire quantity of gas generated available, by closing the top of the furnace, and not allowing any gas to escape into the open air.

This was first effected by Mr. Levick, at the Cwm Celyn Works. The arrangement adopted by him is seen in Fig. 2, Plate 76.

Two cast-iron bearers AA (one of which only is visible in the section), are placed across the furnace, at a depth of about seven feet below the top; upon these a cone of cast-iron B is placed, the base of the cone being less than the diameter of the furnace; a short cylinder C, about 3½ feet deep, is suspended from the filling

plate, resting by a flange, as in the case of the cylinders previously used, upon the lining of the furnace; and a second cylinder D, of about the same depth, rests upon the base of the cone; this second cylinder being larger than the first, and being moveable around it, can be lifted up by means of two bars of iron, or chains attached to it, and passing through openings made for the purpose in the flange of the upper cylinder; E is the pipe for the passage of the gases. When the lower cylinder rests upon the cone, as shown in the diagram, the top of the furnace is closed in entirely, and the space inside the two cylinders can be filled with the materials constituting the charge. Upon lifting up the lower cylinder, the charge immediately falls into the furnace round the base of the cone; and the cylinder being again lowered, the top is once more closed in. By this arrangement all the gases can be economised, and far greater heating power obtained.

Another arrangement effecting the same purpose, was soon afterwards adopted at the Ebbw Vale Works. This is seen in Fig. 3, Plate 77.

Here an inverted and truncated cone A, is fixed in the top of the furnace, resting on the lining by a flange, similar to those employed to suspend the cylinders. The truncated end is closed by another cone B, the apex of which ascends through the truncated end of the upper cone and closes it; this closing cone is suspended by a chain, passing over a pulley, by which the cone can be lowered or raised at pleasure; C is the pipe for the passage of the gases. The lower cone being raised up, the furnace is closed, and the materials wheeled into the upper cone; the moveable cone is then lowered, and the materials at once drop in around it. This arrangement is now in full operation, and working satisfactorily at several of the works belonging to the Ebbw Vale Company. Both at these works, and also at the Cwm Celyn Works, the furnaces with the closed tops work well; they carry equal, if not better burdens than those which are open; they work with equal regularity, and make an equal quantity of iron. The area through which the gases are taken off is in some cases not equal to that of a 3-feet pipe, and much less than that of the smallest of the cylinders which produced such unfavourable results. Consequently, the injurious action of these cylinders could not arise from the decreased

vent permitted to the gases, nor to any obstruction in the blast. The only other way in which the cylinders could produce any effect would be by causing the materials filled into the furnace to fall too much towards the centre of the furnace; thus producing an arrangement of them, which in some way acts prejudicially upon its general working.

By the action of the cones, the materials wheeled into the closed furnaces are scattered round the side of the furnace, and are thus arranged as they would be in open furnaces with wide tops. It thus became at once obvious that cylinders in Wales had been productive of less injurious consequences to the general working of the furnace than those in Staffordshire, because the greater width of the Welch tops had permitted cylinders of from 8 to 10 feet to be employed, whilst in Staffordshire only cylinders of much less size were practicable.

The important effect produced on the working of the furnace, chiefly by an alteration in the arrangement of the materials in the furnace, is a point of considerable interest, but one to which little attention has been hitherto paid.

In practice it has been long known to the best managers of furnaces, that wide tops were desirable, and generally accompanied by increased make, but the precise manner in which wide tops acted was not clearly known until the attempt to use the waste gases led to its evident explanation.

On the Continent, the importance of such arrangement of materials as would facilitate the passage of the blast, as nearly towards the centre of the furnace as practicable, has been known for some time, and acted upon, and the writer was much pleased to find from M. Tunner, Professor of Metallurgy, in Austria, and connected with the Styrian Iron Works, that great increase of make had followed the adoption of wide tops to the charcoal furnaces of that district, combined with a method of filling, by which the coke or charcoal was placed in the centre of the furnace, and the ore and limestone around the sides.

Some few months back a furnace was placed in the writer's hands, which he found provided with a cylinder and other arrangements for taking off the gases. Although apprehensive that the

cylinder would materially interfere with the working of the furnace; yet, as everything was arranged for it, and as it was six feet in diameter, he determined to blow it in without alteration. This was done, the expected result following,—constant slipping, and fretting twyeres, with all their attendant bad results. The stacks were not powerful enough to draw off the gases, unless a closed top was used, and the writer therefore adopted an arrangement somewhat similar to the Ebbw Vale one; the exact fittings and arrangement are shown in Fig. 4, Plate 77. The result was immediate, the furnace worked with great regularity, and carried a good burden, but white iron alone was produced. The burden was lightened, but the iron remained white. A yet farther lightening of the burden was made, but although the cinder was exceedingly grey, still the iron was white. It became evident that a greater proportion of coke would not produce the desired change, and was in fact useless. The white iron was evidently the effect of the closed top. A pipe of nine inches diameter was inserted at the filling place, but with no effect. Another pipe was inserted, and some little change appeared.

It being important to produce grey iron, it was now determined to sacrifice the use of the gases entirely, rather than continue to make white iron. The lid or valve A, upon the main gas-pipe B, and also the covering E, of the gas-pipe CC, were now opened, and a decided change was at once evident. The iron became grey, and the furnace worked with regularity. The white iron had evidently been caused by the pressure produced by the closed top; and so extremely sensitive did the furnace appear to be to the slightest restraint upon the free removal of the gases, that even a strong wind blowing into the open box, through which the gases were principally escaping, would throw the furnace to white iron.

In Wales, where the closed tops are successfully employed, the production of white iron is rather sought for, and hence the tendency in closed tops to produce that quality is no disadvantage. In many cases, however, it must be a fatal objection to their use. But for this objection closed tops would become universal, as they entirely do away with the necessity for a lofty stack, and enable all the gases to be economised.

That the tendency to produce white iron had no connection with the mere abstraction of the gases from the furnace is clearly

shown by the results of the Scotch furnaces, in which they are taken off without employing closed tops. At Dundyvan, especially, great attention has been paid to this point, and the result has shown that the furnaces from which the gases are taken work with equal regularity, and produce grey iron with equal facility to those from which the gases are not taken; and it would be easy to multiply instances of the same result.

The manner of taking off the gases at Dundyvan is shown in Fig. 5, Plate 78. The furnace is 42 feet high, and 12 feet diameter in the centre; it commences to narrow at 12 feet from the bottom to form the boshes and hearth, the hearth being 7 feet wide at the bottom; it also commences to narrow at 8 feet from the top, which at the filling plate is 8 feet wide. Below the part so narrowed, eight flues AAA, four feet high, and eighteen inches wide, placed at equal distances from each other, lead into an annular chamber BB, running round the furnace and continued up to the filling plates, by which it is closed; the pipe C for the passage of the gas is placed nearly at the top of this annular chamber. Sometimes the entrances to the flues are covered by a wrought-iron cylinder, ten feet wide, resting on a flange, let into the lining of the furnace at a depth of from five or six feet below the filling plates, so as to leave a circular space between the cylinder and the lining of about twelve inches width. The cylinder is not shown in the diagram. Although this arrangement works satisfactorily, it is doubtful whether the cylinder is necessary, and, indeed, it is more than probable that it would be destroyed before the furnace had been long in blast.

In many furnaces with open tops, from which the gases are now taken, the use of the cylinder has been abandoned altogether, as needless. Where not used, it is however quite necessary that the openings into the flues should be at a sufficient depth from the top of the furnace, to prevent the possibility of the admixture of the gas with atmospheric air. To effect this, a depth of ten, twelve, or even fifteen feet is sometimes adopted with advantage. The gases pass off more readily at these depths, in consequence of the greater resistance of the superincumbent materials, and they are in a more suitable state for heating purposes.

Fig. 6, Plate 78, shows the arrangement adopted for taking off the gases at a furnace recently erected at Pontypool, and in which it will be seen that the use of the cylinder is abandoned.

In reference to this latter point, it is necessary to consider briefly the composition of the gases, and the chemical changes taking place in the furnace.

The most able investigations of the nature of the gases of the Blast Furnace are those of M. Ebelmen, and almost all the knowledge we possess of their chemical composition will be found in a paper communicated by him to the "Annales des Mines," in 1851, and which contains, not merely a *resumé* of M. Ebelmen's own investigations, but also an examination of those of Messrs. Bunsen and Playfair, as reported to the British Association.

From M. Ebelmen's experiments it would appear that the first action of the blast upon its entrance into the furnace through the twyeres is to produce carbonic acid, by the union of the oxygen of the atmosphere with the carbon of the coke; this is accompanied with the intense heat required for the fusion of the iron ore. The carbonic acid, as it passes upwards, is converted into carbonic oxide, by contact with the carbon of the incandescent coke, above the zone of fusion. As the carbonic oxide ascends higher in the furnace it acts as a reducing agent upon the oxide of iron of the ore, by uniting with the oxygen, by which a considerable portion is again converted into carbonic acid. The gases emerging from the top of the furnace are therefore, from the result of the chemical action now detailed, and also from the carbonic acid liberated from the limestone used as flux, more highly charged with carbonic acid than those which may be taken off at a lower point, and consequently, to the extent of this greater proportion of carbonic acid, they possess less heating power.

Where, therefore, only a portion of the gases are taken off, as in the case of open tops, the depth of the flue is important in reference to the quality of the gas taken off, as well as to its freedom from any admixture with atmospheric air.

In this notice of Ebelmen's experiments, all attention to the composition of the gases, except in reference to their heating power, is purposely omitted.

The results, at which we may be now said to have fully arrived, are the following:—

1st.—That the Waste Gases may be used with great economy in raising steam, and heating the blast.

2nd.—That they must be taken off in such a manner as to prevent their mixing with atmospheric air before they arrive at the place where they have to be applied.

3rd.—That this may be effected in two ways, either by placing the openings for taking them off sufficiently below the surface of the materials in the furnace, or by closing the filling part entirely.

4th.—That the first plan is the most desirable where grey iron is requisite, but where adopted it is necessary that a powerful draught should be obtained by a sufficiently lofty stack.

5th.—That when thus taken off as gas, they can be conveyed to any distance proportionable to the power of draught available, without losing any of their calorific power beyond that lost by simple radiation; the whole of the calorific power to be obtained from their combustion being economised, until atmospheric air is admitted to them at the point where the heating effect is required.

6th.—That no arrangement of the filling place should be permitted which narrows that part to less than eight feet diameter: from nine to ten feet, according to circumstances, being generally the most advantageous.

The CHAIRMAN remarked that it was a very important and interesting subject, and well deserving the consideration of ironmasters. He observed that no heating power, except the actual temperature of the gases, would be lost by the distance of conveying the gases away from the furnace to the place where they were ignited for use; and he enquired whether it had been ascertained what was the temperature of the gases where drawn off from the furnaces?

Mr. BLACKWELL replied that it was not accurately known, but it would not be very considerable, as the gases were not ignited. In one mode of carrying out the principle that was adopted in France, the gases were actually passed through water after leaving the furnaces, to separate all impurities and injurious

matter, and also to prevent any risk of explosion. In that case the only heat lost would be the temperature of the gases in coming from the furnace before they were ignited.

Mr. BENJAMIN GIBBONS remarked that it had been first established by his late brother, John Gibbons, that the size of the aperture at the top of the furnace should be considerably increased over the old practice; the upper aperture he increased from four feet to nine feet, and he (Mr. B. Gibbons) had tried it even ten feet diameter; from eight to nine feet was found the best size, and was indispensably necessary in this district.

Mr. BLACKWELL said that when the top of the furnace was closed, he had found, in every instance that he had tried, the production of white iron; close tops seemed always to produce that result.

Mr. SLATE had been informed that at the Middlesboro' Works in the North of England much stronger iron than they required for castings was produced by closing the tops of the furnaces, though not quite white iron, but a high number of pig; and that a considerable reduction of make was the general result.

Mr. GIBBONS said that a plan that would answer in one district might not succeed in another district, on account of the great difference in the quality of the ores.

Mr. McCONNELL noticed that it was stated in the paper that a greater proportion of carbonic oxide was found at one height than at another, and enquired whether any experiments had been made to ascertain the height from which to get the best result?

Mr. BLACKWELL replied that from twelve to fifteen feet below the top was the greatest depth that he was aware of such a trial having been made. Carbonic acid was generated at the bottom, as the product of combustion, in the neighbourhood of the twyeres; after rising towards the centre of the furnace the carbonic acid became converted into carbonic oxide, by taking up carbon from the mass of incandescent fuel, and carbonic oxide prevailed there; but higher still the carbonic oxide

reduced the iron ore, and much of it became carbonic acid again. At the top of the furnace there was a considerable proportion of carbonic acid, with a portion of carbonic oxide, but in the centre of the furnace there was carbonic oxide alone.

Mr. SLATE enquired whether, if only carbonic oxide existed in the centre of the furnace, any experiments had been tried for drawing off the gases from the centre instead of taking them from the top?

Mr. BLACKWELL did not know of any experiments having been made, for taking the gases from the centre of the furnaces, and he believed that fifteen feet from the top was the lowest that had been tried; but it must be observed that in all probability if the gases were drawn off at a lower level it would reduce the yield of the furnace, because the carbonic oxide was required to reduce the ore of the metal, and it would take away so much of the reducing power of the furnace.

Mr. SLATE remarked that the practical effect would then be to shorten the furnace, and work with a very short furnace, which was known to be bad. He suggested that perhaps the reduced make of furnaces with closed tops was due to the reduction of the quantity of air entering at the twyeres, on account of the resistance to the discharge from the top of the furnace being increased, which would tend to diminish the quantity of air blown in by the same blast engine.

Mr. BLACKWELL did not think that was the case, as it was not always the consequence that the yield was reduced by closing the top of the furnace; at Cwm Celyn a rather greater yield was found with a closed top to the furnace than when open. It must be borne in mind, that from the different composition of the ores in different districts, the plan might succeed in one case, when it would not in another.

Mr. GIBBONS remarked that the Staffordshire ore required a double proportion of limestone compared to the Scotch ore, and therefore more carbonic acid was generated in the blast ·ace.

The CHAIRMAN enquired whether any experiments had been made relative to the actual economy produced by the employment of the waste gases?

Mr. BLACKWELL replied, that at the Ebbw Vale Works they were raising the steam for the blast engines entirely by the waste gases from the furnaces, and also heating the blast; and from 15 cwt. to one ton of coal would otherwise be wanted per ton of iron made for that purpose.

The CHAIRMAN asked whether the plan was found to cause any injury to the boilers, or the heating pipes for the blast?

Mr. BLACKWELL said the action was found less destructive to the boilers than the ordinary fire, because the heat was very uniform, and the boiler was not exposed either to fluctuations in temperature or excess of heat.

Mr. SLATE observed, that the saving of the consumption of slack in South Staffordshire would amount only to 6d. per ton upon the iron, owing to the small cost of the coal usually burnt under steam-boilers.

Mr. BLACKWELL said, that of course there was a great difference in the value of slack with different qualities of coal; in South Staffordshire, from the slack not having a caking quality, it could be used only for steam-boilers and inferior purposes; but in South Wales, most of the refuse slack was a valuable material for making coke, which increased its value very much, and made the saving an important consideration.

Mr. W. MATHEWS enquired what would be the effect on the heating pipes, assuming that the action on the boiler was less prejudicial? There might be a difference perceived in the effect of the action of the gases on the pipes and boilers in different districts from the variation in the quality of the materials.

Mr. BLACKWELL replied, that he had had the plan in operation for three years in some furnaces in Derbyshire, and during that time no instance had occurred of repair being required for the hot-air apparatus; but it had to be opened about every six weeks to clear away the deposit of dust. He understood, how-

ever, that at the Dundyvan Works a considerable loss of heat appeared to be caused by the thick coating of the pipes with dust.

Mr. W. Mathews remarked, that he had lately been over the Dundyvan Works, in Scotland, where the gases had been applied more extensively than elsewhere, and was informed by the manager that he considered they would be as well without this plan, as they found it had a very prejudicial effect on the heating pipes, though less perceptible on the boilers. In Wales they appeared to be using the plan with considerable advantage, on account of the greater price of fuel and coal slack. In South Staffordshire he thought it doubtful that it would be found advantageous; a very slight interference with the regular working of furnaces would be a serious prejudice both to the quality and yield of iron, and would more than counterbalance any economy arising from the application of the gases. He believed that at no other works in Scotland had the plan been persevered in, except at the three or four furnaces at Dundyvan. At the Gartsherrie Works it had been tried and abandoned.

Mr. Gibbons said, that after he had made preparations for the trial of the plan, he came to the conclusion that nothing material was to be saved by the adoption of it but 15 cwt. of slack per ton of iron, costing him only from 1s. to 1s. 6d., and therefore he had not proceeded in the trial of the plan; he had only proposed to try it for the boilers and the hot blast.

The Chairman enquired what was the nature of the dust that was found to collect so rapidly on the pipes of the hot-blast apparatus?

Mr. Blackwell replied, that the chemical character of the dust was not at present well understood, but that the effects alluded to by Mr. Mathews arose simply from the mechanical action of the very large quantity of minute dust given off from the furnace, which could not be cleaned from the surface of the heating pipes so well as from the surface of the boilers, the draught not being sufficient to prevent it from being deposited on the surface of the pipes.

Mr. Slate observed, that a great quantity of coke dust and ore was carried off by the blast from the conducts of the furnace.

Mr. McConnell enquired whether the dust could not be removed by drawing the gases through a screen of wire-gauze, so as to filter the air before entering the hot-blast apparatus?

Mr. Blackwell replied, that the passage for the air from the furnace should be as free as possible, and the wire gauze would cause too much obstruction. In the French works that had been referred to, the air was carried through water to stop all dust and impurities, which appeared to accomplish the object successfully.

The Chairman asked whether Mr. Blackwell agreed with M. Ebelmen's theory of carbonic acid being first produced, then changed to carbonic oxide, and lastly partly converted to carbonic acid again, higher up in the furnace? He could not understand such a process.

Mr. Blackwell said he did not consider himself competent to give any opinion upon the chemical changes occurring in the furnace: he considered the theory a probable one, especially as it appeared to be fully confirmed by M. Ebelmen's experiments, in which the gases were taken off at different heights of the furnace, and subjected to careful analysis.

The Chairman said he could not think that the carbonic oxide took up an atom of oxygen from the oxide of the metal; it was a law of chemical affinity, that the second atom combines with less force than the first. He considered it much more probable that an atom of carbon was taken from the carbonic oxide to unite with the iron; he did not think that the carbonic oxide could de-oxidise the iron, and he could not understand the two reverse processes taking place at the same time in the furnace.

Mr. Blackwell said that when in the Exhibition, accompanied by M. Le Play (one of the Jurors of the Exhibition, and Professor of Metallurgy in Paris) and Professor Faraday, he saw some curious specimens, called "Metallic Sponge," which were formed of pieces of iron ore exposed, when heated, to a current of carbonic oxide, or carburetted hydrogen,

which de-oxidised them. M. Le Play was acquainted with the process before, but it was new to Professor Faraday, who was much interested with the specimens. He (Mr. Blackwell) had not seen the process of de-oxidation, but was informed that it was effected by both means, either by carbonic oxide or by carburetted hydrogen.

The CHAIRMAN proposed a vote of thanks to Mr. Blackwell, for his important and valuable communication, which was passed.

The following paper, by Mr. WILLIAM A. ADAMS, of Birmingham, was then read :—

ON IMPROVEMENTS IN THE CONSTRUCTION AND MATERIALS OF RAILWAY WAGGONS.

The improvements described in the present Paper consist principally in the substitution of wrought iron for wood in the construction of the under-frame of railway waggons.

In the commencement of 1851, the attention of the writer was directed to the construction of a large number of waggons for the conveyance of coal, which were to be hired for a term of years, and in which, consequently, the desideratum to be aimed at was, the construction of such waggons as should commercially be the least costly in maintenance, and at the same time the most lasting in ultimate duration, with due regard to first cost.

Experience had shown, that without large and costly repairs and replacements, the life of an ordinary wood under-frame does not exceed a much longer period than ten years; whilst at the same time the experience of the Great Western Railway had proved that iron under-frames, when properly constructed, continue after many years' work in excellent condition.

In a former paper (see Proceedings, January, 1851), the writer brought before the Institution the question of the substitution of wrought iron of various sections in the place of wood, in the construction of the rolling stock of railways, with the view to economise weight. A careful consideration of the subject, with the practical and scientific aid of Mr. W. P. Marshall and Mr. E. A. Cowper, has enabled the writer to produce waggons with iron under-frames and stanchions, of a simple construction, and at the

same time at only a trifling excess in cost, as compared with the usual wood-framed waggons.

These waggons have been in daily work for twelve months, and about 500 of this construction are now working on the Taff Vale Railway, the Monmouthshire Railway, and the London and North Western, and Midland Railways, and so far as experience shows at present, they are more economical in maintenance than the usual wood-framed waggons, and give promise of a longer life. The experience of these waggons has suggested improvements in some of the minor details of construction, but none in the main points.

The waggon to be described in the present Paper is of a somewhat different class, as the waggons first constructed were adapted for discharging coals at a shipping port by tailboard doors, and the present waggon discharges the coal at the side; but the construction of the under-frame is essentially the same.

The tare or dead weight of this waggon, to carry 6 tons, with ordinary wheels and axles, is 2 tons 19 cwt.; and the tare of waggons of precisely the same class, constructed by the writer with the same wheels and springs, is 3 tons 6 cwt.; the iron-framed waggon being 11 per cent. lighter. It is to be observed, that at the present time there is no possible commercial inducement to the private waggon-owner to reduce the dead weight, but every inducement to reduce the first cost, with due regard to maintenance and durability; and, consequently, no attention has been given to the reduction of the weight in the details of construction, whenever such reduction of weight entails any additional trouble or cost.

The construction of the improved waggon is shown in Plates 79 and 80.

Fig. 1 is a side elevation of the waggon;

Fig. 2, an end elevation;

Fig. 3, a plan of the under-frame;

Fig. 4, a transverse section of the waggon;

Fig. 5, a longitudinal section of the end of the waggon;

Fig. 6, a section of the centre cross bearer;

Fig. 7 shows enlarged sections of the frame-iron A, the cross-bearer C, and the stanchions H, specimens of which are exhibited;

the smaller section of frame-iron D is used for a smaller class of waggon.

The soles AA, and head-stocks BB, are constructed of the larger frame-iron, which is 8 inches deep, $4\frac{1}{2}$ inches wide on the bottom flange, and 13-32nds of an inch thick; the weight is 20lbs. per foot. The section of the frame-iron is designed according to the principle discussed in the former Paper, so as to obtain, with the least weight of material, the greatest amount of strength under the particular circumstances to which it is subjected; the mass of metal in the section is situated at the three extreme points, vertically and horizontally, to afford the greatest strength, and the ends are thickened to 11-16ths of an inch at the top, and 13-16ths of an inch at the bottom. This frame-iron is rolled in a similar manner to ordinary angle iron. The corners of the frame are mitred, being sawn cold by a machine set at an angle of 45°, which ensures truth in the joint. On the under side the corners are secured by a plate 5 inches wide by $\frac{3}{8}$ inch thick, fixed with three $\frac{3}{4}$-inch rivets at each end. The top of the frame-iron is secured by a knee $2\frac{1}{4} \times \frac{3}{8}$ inch, fixed with three $\frac{5}{8}$-inch rivets on the side, and two at the end. Below this the corner is further secured by an angle iron knee $3\frac{1}{2} \times \frac{1}{2}$ inch, fixed to the side with two $\frac{5}{8}$-inch rivets, and to the end with one rivet, the other hole taking one of the bolts of the buffer-block. A little draw is given to all the rivet-holes, by which means the two pieces of frame are forced together at the corner, making a secure and rigid joint.

The cross bearer C in the centre is made of T iron, 6×3 inches, and $\frac{3}{8}$ inch thick; it is notched at the ends, to fit over the bottom flange of the frame-iron, to which it is secured by two $\frac{3}{4}$-inch rivets through the bottom, and an angle iron knee at the side. The cross bearer and head stocks, where weakened in the centre by boring for the draw-bar, are flitched on each side by two $5 \times \frac{3}{8}$ inch plates.

The diagonals DD are of fir, 11×3 inches, laid flatways; their outer ends abut against a piece of 2-inch angle iron, rivetted to the head stocks, and they rest upon the lower flanges of the frame-iron and of the cross bearer in the centre, being packed with fir packing to bring the upper side of the diagonals flush with the under side of the floor.

The floor E is of fir, $7 \times 2\frac{1}{2}$ inches, laid longitudinally, and it is fitted tight inside the frame, flush with the top of the frame iron, abutting against the thickened top edge of the frame, so as to form a very strong and rigid bracing to the frame. The floor rests upon fir packings at the ends and centre, and is spiked down to the four diagonals. It is to be observed that one important advantage in this method of flooring is, that the floor forms an entire panel, bracing the under-frame in all directions, and materially assisting the end resistance of the frame at the buffer-blocks.

The buffer-blocks FF are of elm, and fixed by three $\frac{3}{4}$-inch bolts, with heads inside, and nuts recessed in the face of the buffer-block, for the convenience of tightening up when they loosen in work.

The axle-guards GG are two pieces of plate, $\frac{5}{8}$ inch thick, and fixed with four $\frac{3}{4}$-inch rivets through each leg. The fixing of these guards being made with short rivets, measuring but one inch length between thc heads, effects a perfectly firm job, and none of them have been found to loosen in work, with the exception of one or two cases, where the rivet-heads have broken off, from imperfect workmanship or material.

The waggon is mounted on the improved springs, SS, that were brought before the Institution by the writer in a former paper (see Proceedings, January and April, 1850), which reduce the total weight 148 lbs. in the set of four springs, ond the expense proportionally, with the same extent of elastic action as the ordinary springs. The spring shoes are of cast iron, fixed with a $\frac{5}{8}$-inch bolt to the bottom flange of the frame-iron, and prevented from turning round by a lip at the back, fitting against tho frame.

The stanchions, HH, to support the ends are made of tramway iron, $3\frac{1}{2} \times 2$ inches, and are fixed to the frame by two $\frac{3}{4}$-inch rivets. A small cross bearer of hard wood is fixed between the frame and the diagonal, to carry the side knee.

The construction of an Ordinary Wood-framed Waggon, of the same size and class, is shown in Figs. 8, 9, and 10, Plate 80. Fig. 8 is a side elevation, Fig. 9 a cross section, Fig. 10 a plan. The soles, AA, and head stocks, BB, are of oak, $12 \times 4\frac{1}{2}$ inches, mortised together,

and secured by transverse bolts through the entire frame. The floor is laid crossways upon the soles: with the same height of buffers, this waggon carries the load 6¼ inches higher than the iron-framed waggon.

The objects aimed at in the construction of the iron framed railway waggon described above, are—

First, increase of durability, and consequent economy in the expense of maintenance, by the substitution of iron for wood in those parts that are subjected to constant strains and concussions, tending to rack the joints and make them work loose. In wood framing this action exposes it to great injury, from wet penetrating the joints; and the wood is liable to be shaken and split; but in the iron framing the joints are fitted, iron and iron, with very short bolts and rivets, and are as rigid and durable as boiler-work; and the iron, when protected from oxidation by paint or tar, is of great durability, remaining nearly as sound as at first, after such a number of years' work as is the ordinary limit of the work to be got out of a wood frame.

The second object is diminution of weight in the frame, and consequent economy in the dead weight to be conveyed and the expense of locomotive power. This reduction of weight amounts to 11 per cent., and the resulting economy is an important consideration, as a proportionate increase of load can be conveyed at the same expense of locomotive power; but at the same time it must be remarked that this point has, from commercial reasons, received but little or no attention at present, and the weight of construction is capable of much further reduction.

Mr. McConnell considered that the waggon that had been described was an important step in the right direction, both as regarded durability and reduction of weight; he had suggested some time since to Mr. Adams, the consideration of a reduction in the dead weight of railway waggons, having had experience of the cost of dragging the present great proportion of dead weight. He thought the construction adopted by Mr. Adams was very good, and that he had arrived at a good practical

section of angle iron, indeed, the very best section next to a tube. Economy in dead weight was a very important subject, and this Institution, by such Papers, might effect great economy in the expenses of railway working, by reducing the dead weight to be conveyed. He considered that much more might be effected in that respect than was commonly supposed.

Mr. ADAMS observed, that his first attention had been drawn to iron-framed waggons, by trying to reduce the weight; but in the present waggon his only object had been to obtain greater economy in durability and expense of maintenance, without exceeding the ordinary expense of construction.

Mr. H. WRIGHT remarked that he had many thousand waggons at work on the North Staffordshire and other lines, a number of them iron-framed, though mostly wood-framed, and he found that there was a greater expenditure in the repairs of the iron-framed waggons. The greatest increase of expense was mainly in the failure of the bolts that fixed the axleguards, which get sheared off by the sharp edges of the iron plate, from the rough usage to which the waggons were subjected in shunting about at stations; but in wood-framed waggons the elasticity of the wood saved the bolts from breaking with a sudden blow. The waggons got so seriously injured by the blows that the wheels received by being run against the stops fixed at the ends of sidings, and this made the fixing of the axle-guards an important matter. He quite agreed with Mr. Adams that it was a great advantage to reduce the dead weight.

Mr. E. JONES thought that one of the greatest sources of injury in knocking about waggons on railways, was from the want of spring buffers; they should all have spring buffers at one end, and the extra expense would be amply returned in the saving of injury in wear and tear.

The CHAIRMAN said that he agreed in the opinion that all railway stock should have spring buffers; it would cause a great saving in the expense of repairs, and greatly increase the durability of the waggons; but if there was one only end of

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each with buffers, the two dead buffers would be often liable to get together, which would be as bad as no spring, and there could be no complete carrying out of the principle without spring buffers at both ends.

Mr. SLATE thought that railway waggons should not be required to be built for running off the line. It was an important point to Railway Companies to avoid running off the line, and the knocking about of waggons at the stations, and such bad usage should be prevented. A saving in dead weight would have the advantage of diminishing the injury in accidents, if combined with equal strength.

Mr. ADAMS enquired whether, in the iron-framed waggons mentioned by Mr. Wright (in which the axleguard bolts were found to shear off), the axleguards were not of the old shape, fixed on only with three or four ¾ inch screw-bolts, and the nuts working loose, would make them liable to break off. He had not found any proof of deficient strength in all the number he had made, in which eight ¾-inch rivets were employed to hold each axleguard.

Mr. H. WRIGHT replied that in some cases only four screw-bolts were used, but they broke off without the nuts coming loose. The bestform of axleg uard for the purpose, he thought, was that shown in the wood-framed waggon (Plate 80), which had two side arms, giving great support by the extended leverage.

The CHAIRMAN remarked that that certainly was the best form of axleguard, and it would be best for the iron-framed waggons also, which would make a good job. It was certainly a most important point to reduce the dead weight, but at the same time the waggons must be made strong enough to stand running off, to diminish the length of delay in case of accidents; all running stock must be strong enough to bear accidents. He proposed a vote of thanks to Mr. Adams, which was passed, and expressed a hope that this course of improvement would be still further pursued.

The following paper, by Mr. PAUL R. HODGE, of London, was then read :—

ON A NEW SELF-LUBRICATING AXLE-BOX FOR RAILWAY ENGINES AND CARRIAGES, AND A SELF-ACTING SPRING CROSSING POINT.

No part of the machinery of a railway requires constant lubrication more than the axle journals of locomotives, tenders, and carriages, as the heating of one journal in the whole train is sufficient to produce the most serious results, not only in delay to the traffic, but endangering the lives of the passengers in the train.

Notwithstanding the great attention this point has received, scarcely a train that passes over our roads (in the summer more particularly), but some one or more of the axle journals heat. In one instance the writer experienced, the whole train had to be passed into a siding for more than two hours, before it could again proceed on its journey. He was induced, through what he had experienced of the difficulties attendant on the use of grease as a lubricator, and from what he knew of the use of oil in the United States, to write to the inventor of the best lubricating box in that country, knowing that the difference of cost of lubricating was more than one-half in favour of oil, with a proper box. He obtained a patent in this country for the inventor, and on application to Mr. J. E. McConnell, of the London and North Western Railway, a trial of the axle box was at once made on some of their carriages.

On no railway in the United States is grease used as a lubricator; many patents have been taken out in that country for axle boxes, but the plan now brought before the meeting seems to be preferred, and is universally adopted. The average distance that carriages run there before any additional oil is supplied to the boxes, or before the journals and brasses are examined, is 8000 miles. This fact has been fully corroborated by the working of these boxes on the London and North Western Railway. The first boxes were put on the tender of No. 182 Engine, which was immediately put on to the most trying work, during hot weather, sometimes running express trains at the highest speeds, and at other times at the worst possible work,

ballasting; and yet after running 6000 miles in four months, without any additional oil, the journals and brasses were in as perfect a condition as when new.

This axle box is shown in the accompanying engravings.

Fig. 1, Plate 81, Longitudinal section;

Fig. 2, Transverse section;

Fig. 3, Front elevation.

Fig. 4, Back elevation.

A, the axle; B, the journal; CC, a wrought-iron collar, shrunk on to the axle, having a groove turned into it, to receive the leather DD, which is shown separately in Fig, 5.

EE the brass bearing, FF the upper chamber, which is filled full of cotton waste, flax, sponge, or any other capillary material, to retain and pass the oil up to the journal; G is the lower or secondary chamber, for the reception of the dirty oil, which finds its way down the space at the back of the bridge wall, with a tap screw at the bottom to let out the oil; H, an iron plate bolted to the back of the box, to keep the leather flange to its place; I, a covering plate bolted on to the front of the box, which is the only opening into the box, besides the hole K for supplying oil, closed by a screw.

The results of the trial of the new axle boxes in the tender No. 182, upon the London and North Western Railway, have been officially reported as follows, to Mr. McConnell by his assistants. The axle boxes have, up to 20th Sept. last, run 5743 miles; the bearings have been examined, and are found in very satisfactory state. No oil has been supplied since the first day of running, four months previously; 10 quarts of oil have been supplied to the boxes altogether, and 5 quarts have been drawn off during the time from the bottom chamber, which is still good oil for screwing, drilling, and other ordinary work; the oil remaining in the boxes is considered sufficient, without more being added, to run at least from 3000 to 4000 miles more. The journals and brasses are wearing beautifully, with faces as though polished in the latter; and a great advantage is found, that the great wear endways does not take place on the brasses, as in the ordinary boxes using yellow grease or

tallow. The cost of lubrication is greatly reduced, as appears from the following account of the comparative consumption of the above tender with the new axle boxes, and another tender exactly similar, except that it was fitted with old boxes on Normanville's plan, using tallow, both tenders having run the same distance, 6000 miles, under the same circumstances of trains, and the weather being dry and dusty nearly the whole of the time.

NEW AXLE BOXES.

	s.	d.
Oil put into the boxes at starting, 10 quarts at 9d.	7	6
Credit by 5 quarts drawn off from the bottom chamber, at 6d.	2	6
Actual cost of oil	5	0
Cotton waste, 4 lbs. at 2d.	0	8
Leathers, 4½ at 1s.	4	6
	10	2

Actual cost per day, 1.54d., or ... 1½d. per day.

OLD AXLE BOXES.

Tallow required per day, 2 lbs., at 4½d., or ... 9d. per day.

Saving per day on the 6 New boxes, ... 7½d. per day.

	Cwt.	Qrs.	lb.
Weight of the 6 Old axle boxes	3	1	0
Weight of the 6 New axle boxes	1	2	20
Saving in weight of the 6 New boxes ...	1	2	8

The advantages of this Axle box over those now in use are—

Firstly—The perfect exclusion of dirt or grit from the box, by means of the leather and wrought-iron collar.

Secondly—The certainty of constant and never-failing lubrication to the journals and brasses by means of the capillary medium placed in a separate chamber, and detached from the back of the box by means of the bridge wall, so that the hydraulic lead of the oil can be carried much higher than the joint of the leather and

collar, allowing the *upper chamber* to be full of oil if necessary, while it is impossible that any oil can leak out at the back.

Thirdly—The provision of a secondary or under chamber for the dirty oil to drop into, from which it is drawn off, refined, and again returned to the upper chamber, or is used in the machine shop for drilling, cutting bolts, and many other purposes, and is equally good as new oil.

Self-acting Point for Crossings.

This crossing point, commonly called the Frog Point, is generally used on the railways of the United States.

It is unnecessary on the present occasion to detail to practical engineers the difficulties and likewise danger experienced by running engines and carriages at high speeds over the present crossings. It will be sufficient to describe the improved crossing point, which is brought before the meeting as a remedy for the evils attendant on the crossings now used.

Fig. 6, Plate 82, is a plan of the simplest construction of the spring crossing, and Fig. 7 a transverse section. A A is the main line rail, and B B the cross line, the crossing point C being the same as usual, but the wing rails D D are each moveable on a stud at the end, acting like switches, and two pins E E, are fixed to them on the under side, passing through slots in the bed plate. An India-rubber ring, G G, is passed round these studs, which draws them together, and keeps the moveable tongues D D in close contact with the crossing point, so that the rail presents an uninterrupted surface for the trains running through either line, the flanges of the wheels opening the tongue on the opposite side, which closes again directly they have passed.

Fig. 8, Plate 83, is a plan of another construction of the crossing, and Fig. 9 a transverse section. In this the India-rubber spring GG acts as a buffer spring, being put upon a horizontal spindle H, which passes through the two studs E E on the moveable tongues D D, and has a washer at each end to confine the India-rubber buffer springs, which are constantly pressing the moveable tongues against the fixed crossing point.

The main feature in both of these arrangements is in having a complete uninterrupted tread for the wheel whilst passing through the crossing, at the same time ensuring a certainty of action in whichever direction the train is passing.

The only difference between the two buffer springs and the round spring of India-rubber is, that the former is compressed and the latter is distended; but either plan is found to work with certainty, and the India-rubber spring is found to be very durable.

Mr. McConnell said that he believed the statement in the Paper was correct about the results of the trial he had made of the axle-box. There was a perfect exclusion of dirt from the journal, and the keeping it constantly in contact with the oil was an important advantage. He was satisfied they must, ere long, abandon grease for oil; there was a great loss of power from defective lubrication of the carriage and waggon journals in cold weather, as there was no lubrication in action on first starting, until the journals got heated, and then they were liable to get too hot, and the grease ran away, and was scraped off the outside of the boxes and put in again mixed with grit at the stations. Oil was generally ready for action in any weather, and he thought railway companies must ultimately adopt oil for all moving journals, particularly with the present increase in the speed of trains, and the weight on the working bearings.

Mr. Lea, of London, mentioned a new material for lubrication that he was bringing into application; it had been tried some years since by Mr. Ramsbottom, with very satisfactory results; but further trials had been suspended till now, from difficulties of the inventor, who was now dead. This lubricating substance consisted of a peculiar semi-fluid composition, applicable to the present axle-boxes; oil was the basis of the composition, but thickened with India-rubber and other materials; it had an affinity for the iron bearing, which prevented the displacement of the material from the rubbing surface. The manufacture of the material was not expensive, costing

only 4d. per lb.; and when charged at 16d. per lb. it had been found in the trial made that there was a very considerable saving in the cost of lubrication compared with the ordinary grease or tallow. He wished to make a further trial of it on railways, and thought it would prove an important improvement. There was a great advantage in this plan, from requiring no change in the present axle-boxes. No ordinary pressure in the bearings could squeeze out the lubricating material; therefore it remained between the surfaces, preventing contact, and consequently preventing any heating by friction.

The CHAIRMAN said they would be glad to have the results of a further trial of the new lubricating material, and to receive more particulars at the next meeting.

Mr. E. JONES observed that the use of a spring crossing point was not new in this country; it had been in regular operation, for six years, on the Great Western Railway, also on the Bristol and Exeter and the South Wales lines; and fourteen years since he remembered something of the kind in use on the Hartlepool Railway. He had made several hundreds with flat steel springs, originally of his own invention, at Bridgewater, for those lines. A 2½-feet spring was used for crossings of 600 feet radius, and a 3½-feet spring for 900 or 1000 feet radius, according to the curve. The springs were 2½ inches wide and ¾ inch thick, tapered to 3-16ths of an inch. He gave a sketch of the spring crossing (see Plate 83, Figs. 10 to 14). He had tried some with India-rubber springs, but did not find them so lasting as steel springs, which were all adopted. The steel springs were found to answer the purpose very satisfactorily, and there was not experienced any objection to them in working. They were very durable. There had been some instances of springs breaking, but they were very easily replaced. The crossings were made safe in any case, though broken, by the tongues being prevented from rising or getting wrong, even if the bolt broke or came out, as the moving tongue was bound down by strong clips at each end.

The CHAIRMAN said he remembered that on the Stockton and Darlington Railway spring crossing points were tried at one time, but were abandoned, from getting knocked to pieces with the increase of speed and weight in the engines. He was not before aware of their general use in America. He doubted their permanent durability and use where there was large traffic.

He thought the axle-box described in the paper was a very successful application of oil, and was very likely to accomplish an important desideratum in the satisfactory employment of oil instead of grease, it being undoubtedly a much more correct material for lubrication.

Mr. ADAMS inquired about the working of Normanville's and other oil-tight grease-boxes—what was the result found in working? He observed that an axle-box had been brought out some years since by his Father, for a similar purpose, with a leather collar, to prevent the waste of grease or oil.

Mr. H. WRIGHT said that Normanville's first axle-box was intended to feed in front, with the supply of grease below the journal, and filled up close to it. But the grease was found to lose its nature and get hard below the journal; and the box was then improved by keeping the grease in a chamber above, as in the ordinary boxes. He had known several kinds of oil-boxes, but they were all liable to the spilling of the oil from side blows and oscillations. The employment of the cotton waste in the axle-box, described in the paper, he thought was decidedly a good plan to prevent the oil from spilling over, and he enquired the result that had been found in the trial on the London and North-Western Railway?

Mr. McCONNELL replied, that there appeared to be no spilling or loss of oil, and the dust and grit were effectually kept out of the box. The oil drawn off from the bottom chamber was very black and thick, and not suitable to use again in that state, though it might be fit for drilling purposes, &c.; but after being properly purified, it was very good for lubrication again. There was a bridge at the back of the axle-box, just high enough

to prevent the oil from flowing off; the oil did not come into contact with the leather joint, which was only to prevent the entrance of grit and dust.

Mr. E. JONES said he remembered that on the North Union Railway, many years since, Mr. Williams had tried a collar or picking-up ring on the middle of the journal, which dipped into cotton waste saturated with oil whilst revolving, continually picking up a supply of oil for lubricating the journal.

Mr. CHELLINGWORTH remarked, that there was a plan of lubrication with a cork ball, about one inch diameter; two of these balls floated on the surface of the oil, rolling against the journal to distribute the oil. He believed it was a French invention, but did not know the result of its application.

Mr. McCONNELL said he was not acquainted with that plan. The leather in the new axle-boxes was not found to wear away, and appeared likely to last a long time, as there was no pressure or strain upon it; the leather was not bent, but simply fitted easily into the groove in the iron collar, which was shrunk on to the axle.

Mr. H. WRIGHT observed, that the leather would probably wear the iron away before it was worn away itself; he had found it necessary in Normanville's axle-box to increase the surface of contact by a longer bearing of the leather collar on the axle, to allow for the wearing away of the iron by the constant grinding action with the particles of grit.

Mr. ALLAN remarked, that he had used sponge in the axle-boxes of engines for the last ten years, and found the results very satisfactory. They found that the consumption of oil, which was previously six to eight quarts for the 100 miles trip between Birmingham and Liverpool, was now reduced to one quart, partly by the introduction of sponge in the axle-boxes of the ten bearings of the engine and tender. The plan still continued very successful, and they had adopted it generally in their engines and tenders.

The CHAIRMAN enquired whether the sponge was placed below, to catch the oil falling from the bearings? and was the oil fed from above as usual?

Mr. ALLAN said that was the mode of application; the sponge wiped up the oil, thus preventing the loss of the oil that would have dropped from the journal, and keeping the journal constantly oiled smoothly over.

Mr. MCCONNELL thought that sponge would be liable to get hard with a hot axle, and that the cotton waste would be a better plan. In the new axle-box, the great improvement, he considered, was in having the reservoir of oil below the journal instead of above; this appeared to be the best mode of application, as any grit or impurities in the oil settled to the bottom, and were prevented from coming in contact at all with the journal by that arrangement, which could not be entirely prevented when the reservoir was above the journal. The lower separating chamber for the waste oil was also an important improvement, keeping up a constant gradual separation of the impure oil, and affording a great means of economy in using the oil over again, after being purified. The leather collar was a very effective and simple contrivance to exclude the grit and dust, which were a great source of expense and injury in the ordinary axle-boxes.

Mr. SLATE asked what was the comparative economy of the American axle-box and Mr. Allan's plan? In the latter plan, there was consumed one quart of oil for 100 miles, but in the other there was said to be five quarts for 6,000 miles, or one quart only for more than 1,000 miles.

Mr. ALLAN remarked, that the one quart of oil that he had mentioned was used for all the bearings, moveable joints, &c., of the engine and tender, not for the axle-boxes alone, as in the trial of the new axle-box; and he had no means of knowing what proportion of the whole was consumed by the axle-journals.

The CHAIRMAN asked Mr. Allan to give a sketch of his sponge axle-box, with an experimental trial on the consumption of oil in the axle-boxes alone, independent of the rest of the engine.

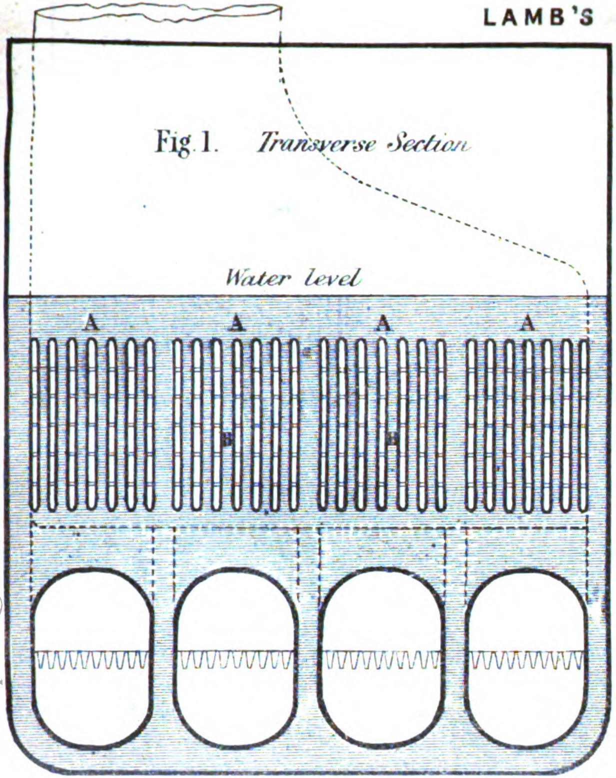
Mr. ALLAN said that he would give it at the next meeting of the Institution, and would try for a week or two the actual consumption of oil in the axle-boxes, to ascertain the proportion as far as was practicable.

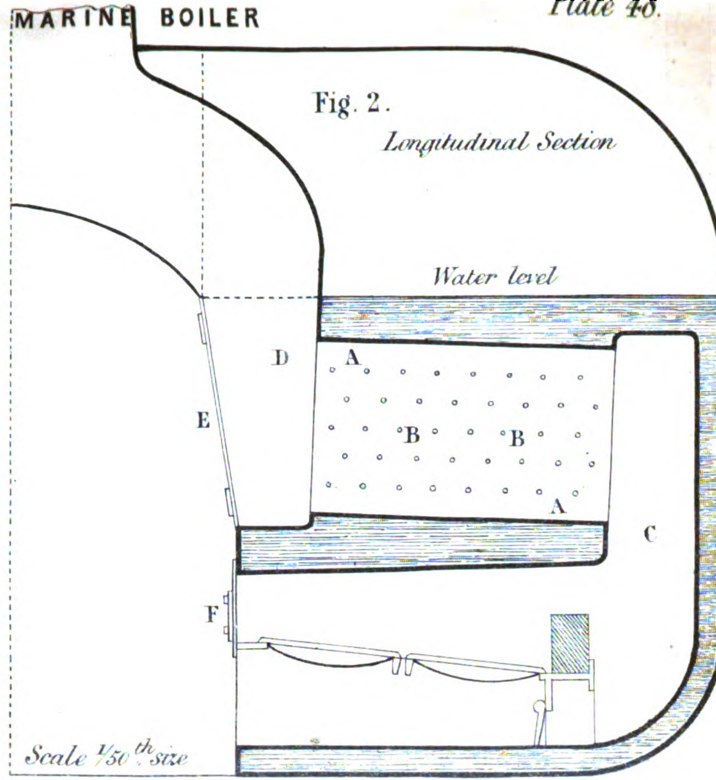
Mr. FORSYTH (of Wolverton) remarked, that one circumstance had not been mentioned, in the description of the new axle-boxes tried on the London and North Western; the cotton was rammed in tolerably tight from the front, filling the boxes up solid except against the ends of the axles. The cotton was put in dry, and it became gradually saturated, by pouring in oil from time to time at the top hole; it would continue to absorb oil for several days. The surface of the cotton waste, when examined after running the 6000 miles, was like a metallic polished surface next the journal, but still it was found saturated with oil close up to the surface of contact. The leathers were cut straight up ¾ inch from the axle, but not bevilled, to get them into the groove of the iron collar, but no leakage was found to take place, as the cotton was not over-saturated, and the oil never came in contact with the leather so high up as the cut.

The CHAIRMAN proposed a vote of thanks to Mr. Hodge for his Paper, which was passed, and expressed a wish for further information about the results of trial of the axle-box.

The Meeting then adjourned; after which specimens were exhibited, by Mr. J. McConochie, of Wednesbury, of a new Permanent-way Chair for Railways.

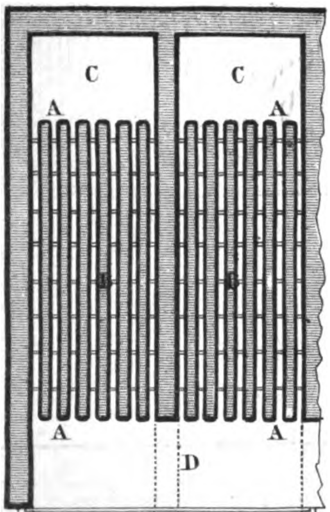
LAMB'S MARINE BOILER





LAMB'S MARINE BOILER.

Fig. 3.
Plan of Boiler



Scale 1/50th size

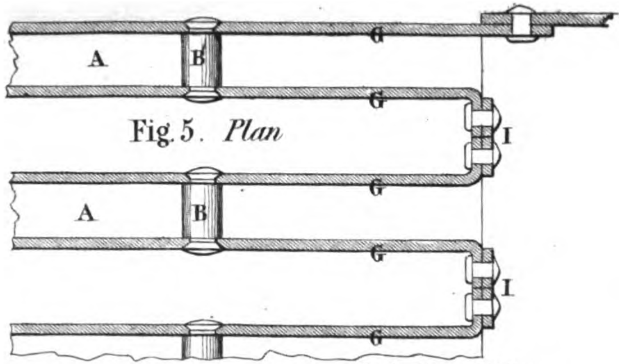


Fig. 5. *Plan*

Details of Flues

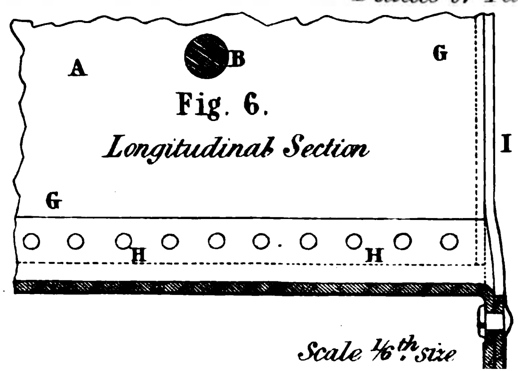
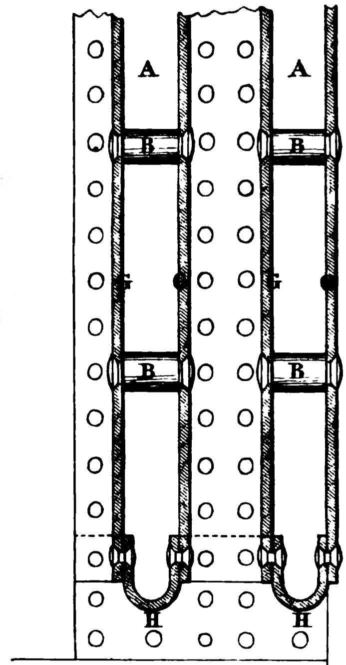


Fig. 6.
Longitudinal Section

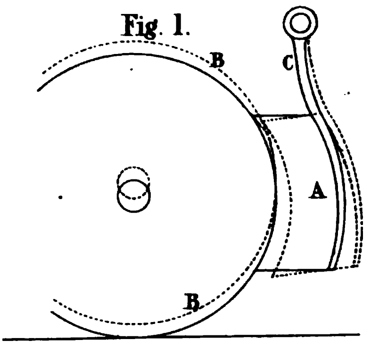
Scale 1/6th size

Fig. 4.
Vertical Section



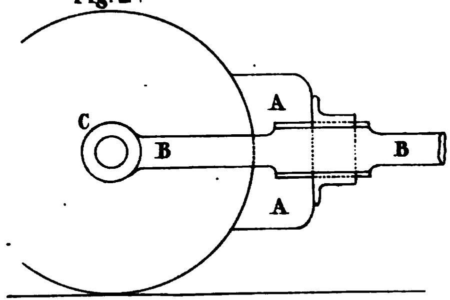
RAILWAY CARRIAGE BREAKS.

Fig. 1.



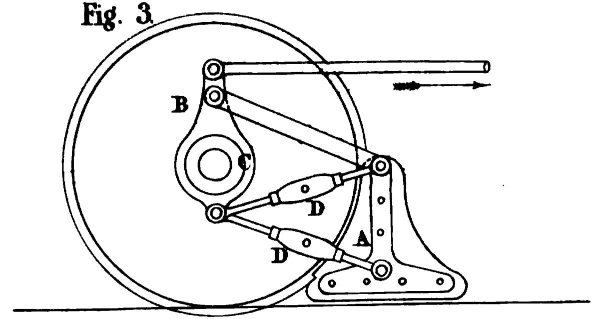
Hanging Break

Fig. 2.



Sliding Break

Fig. 3.



Lee's Break

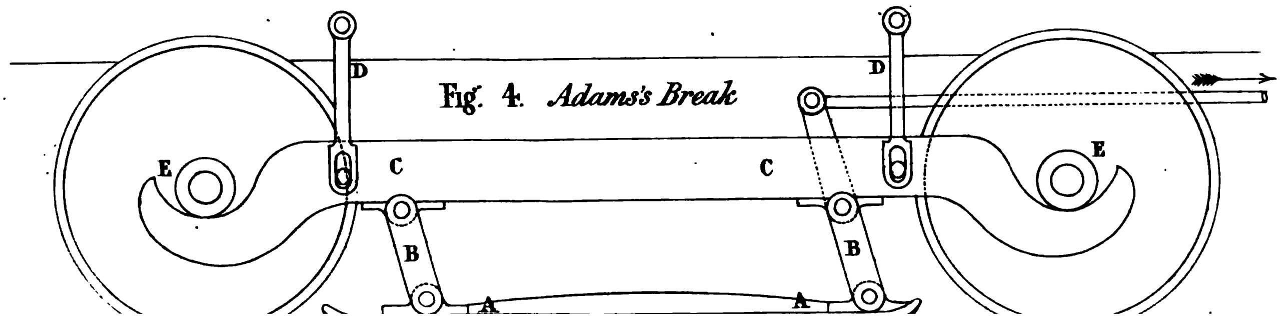


Fig. 4. Adams's Break

RAILWAY CARRIAGE BREAK.

Fig. 5.

Handley's Break.

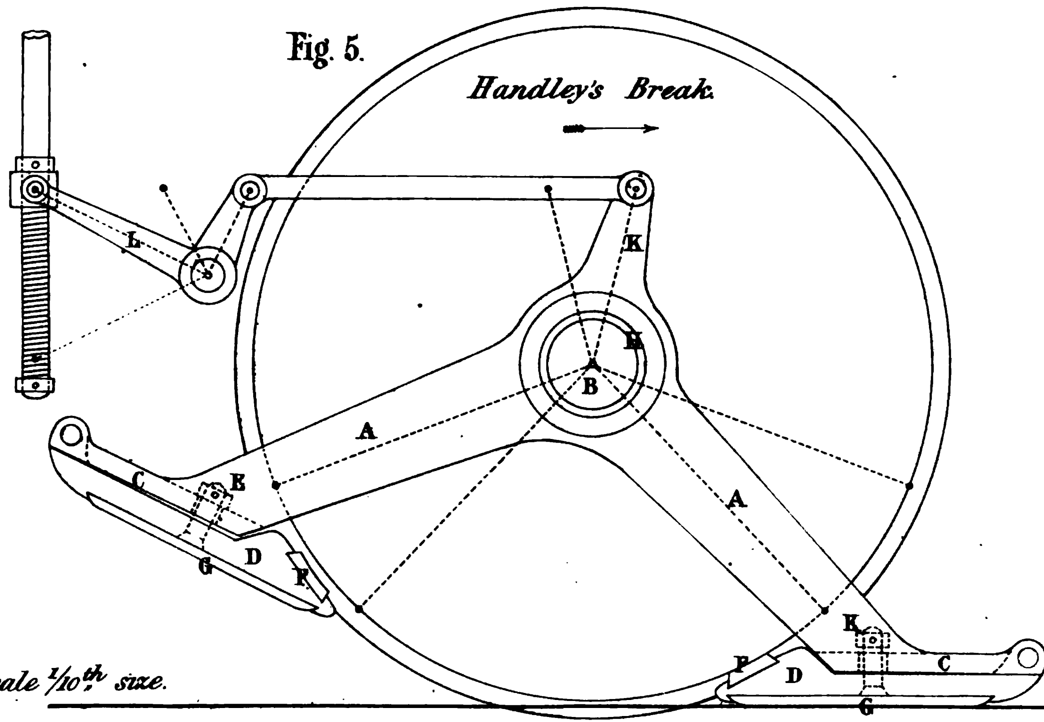
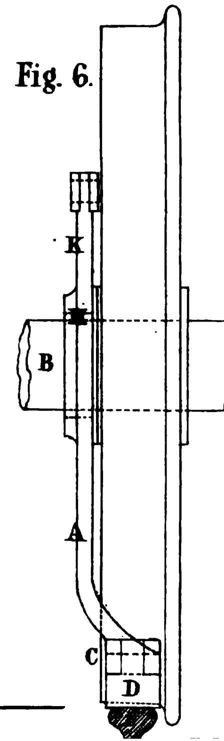


Fig. 6.



Scale 1/10th size.

SAMUEL'S
CONTINUOUS EXPANSION ENGINE.

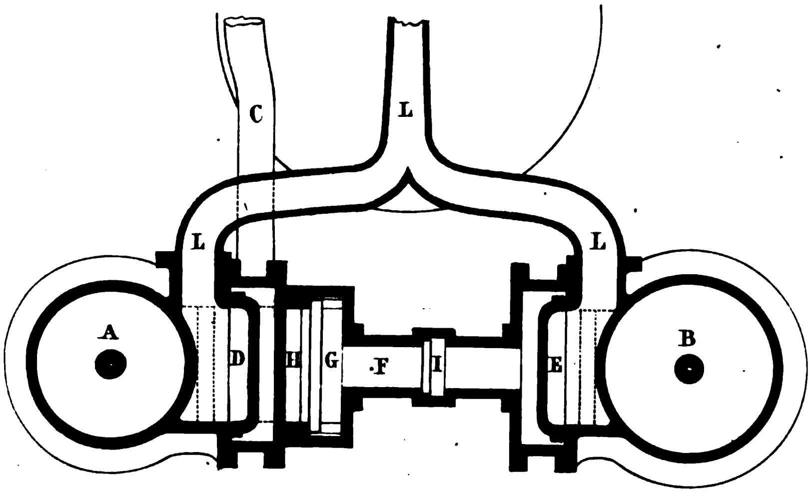


Fig. 1. *Vertical Section*

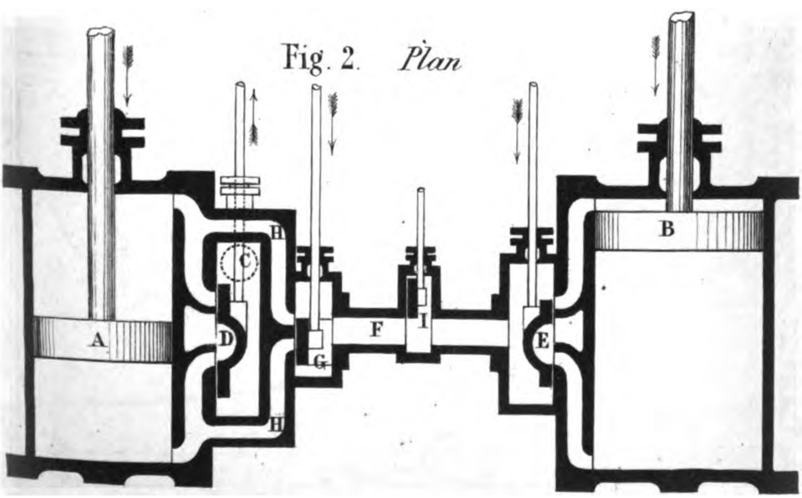


Fig. 2. *Plan*

Scale 1/20th size

CONTINUOUS EXPANSION ENGINE.

Diagrams showing the Variations in Rotative Moving Power, during one half revolution of the crank.

Fig. 3.
Cornish Engine

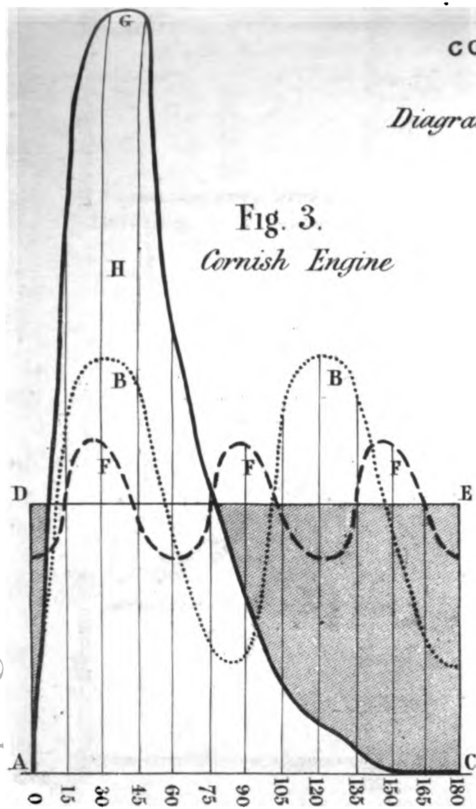


Fig. 4.
Continuous Expansion Engine.

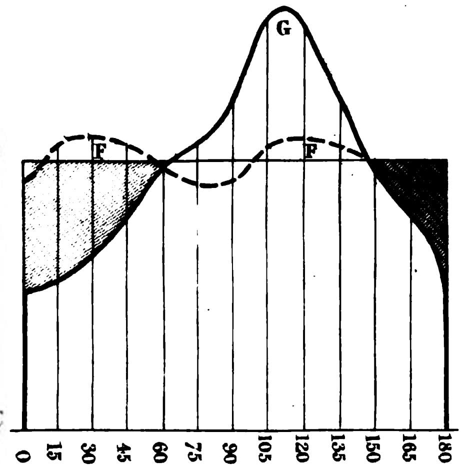
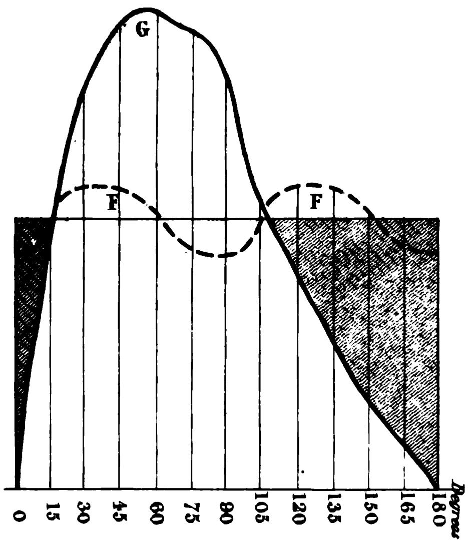


Fig. 5
Woolf's Engine



CONTINUOUS EXPANSION ENGINE.

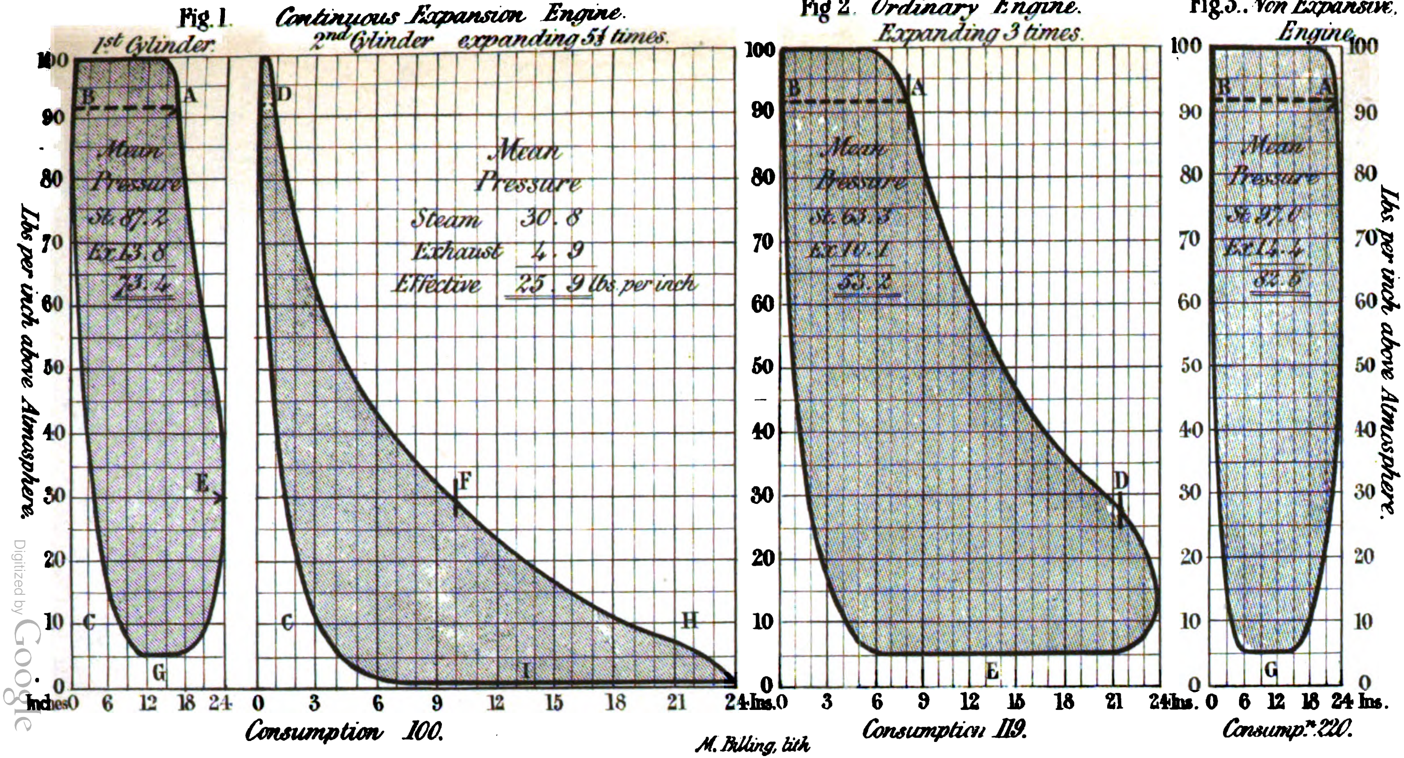


Fig 2. *Plan.*

Fig. 3. *Thermometer.*

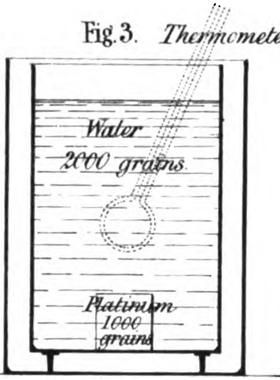
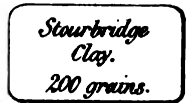


Fig. 4.

Fig. 5.



Scale ½ size.

Full size.

EXPANSION OF STEAM.

Fig. 1. *Indicator Diagrams with very slow motion. from Caledonian Locomotive No. 13.*

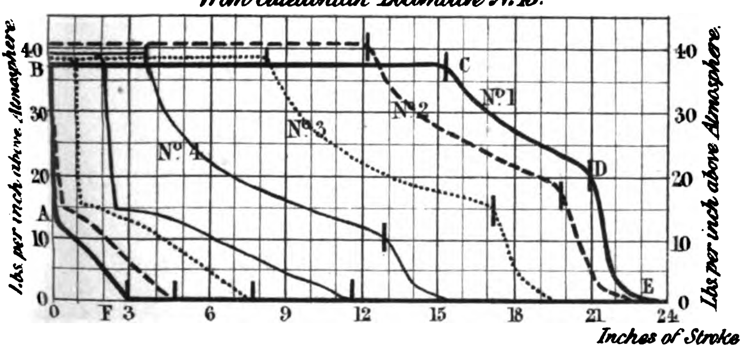


Fig. 6. *Diagram of the actual consumption of Steam Per Horse power per hour.*

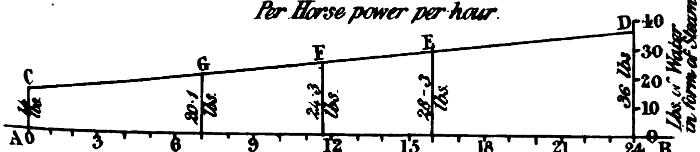
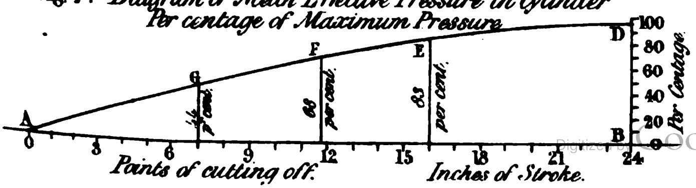


Fig. 7. *Diagram of Mean Effective Pressure in Cylinder Per centage of Maximum Pressure.*

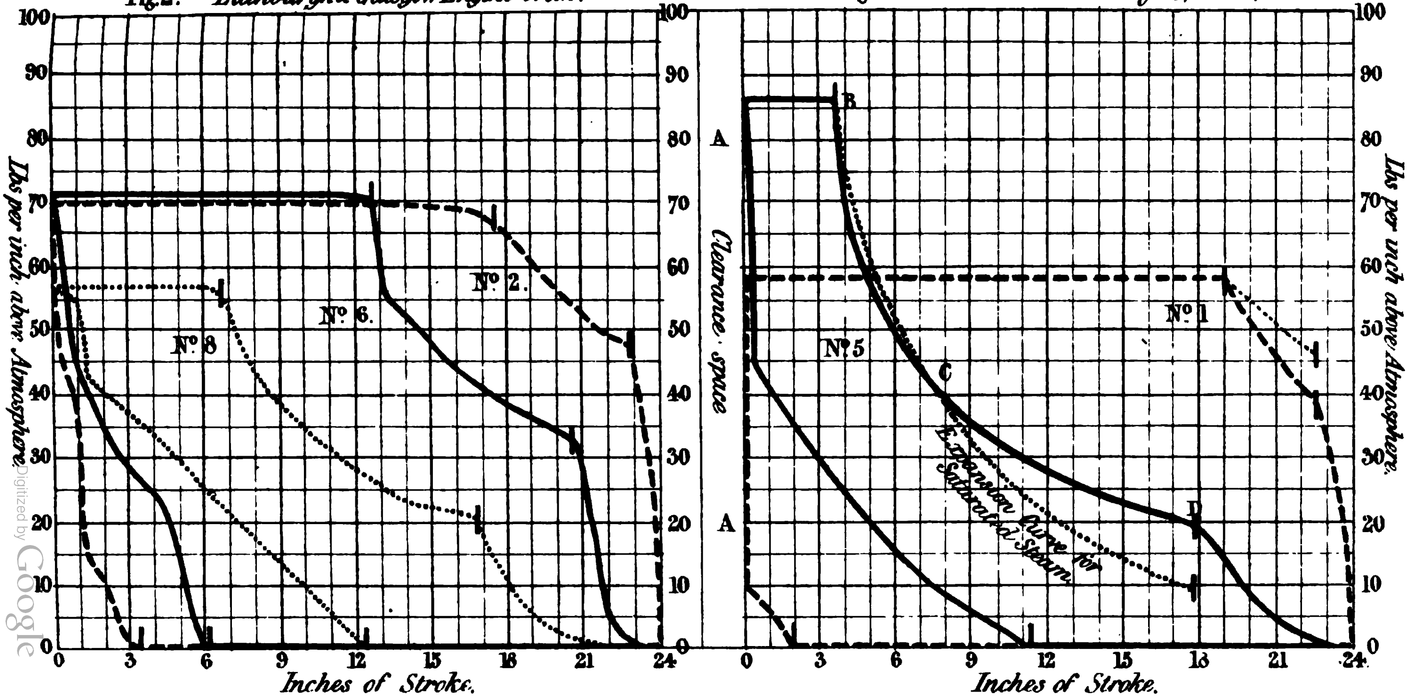


EXPANSION OF STEAM.

Indicator Diagrams from Locomotives at very slow motion.

Fig. 2. *Edinburgh & Glasgow Engine Orion.*

Fig. 3. *Caledonian Goods Engine, No. 125.*



M. Billing, lith.

EXPANSION OF STEAM.

Indicator diagrams from Great Britain Locomotive.

Fig. 4. *At 17 Miles per hour.*

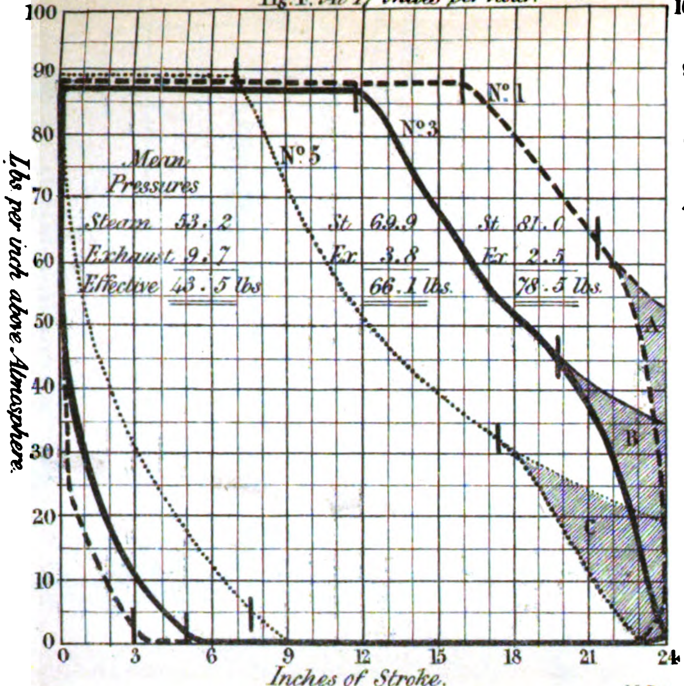
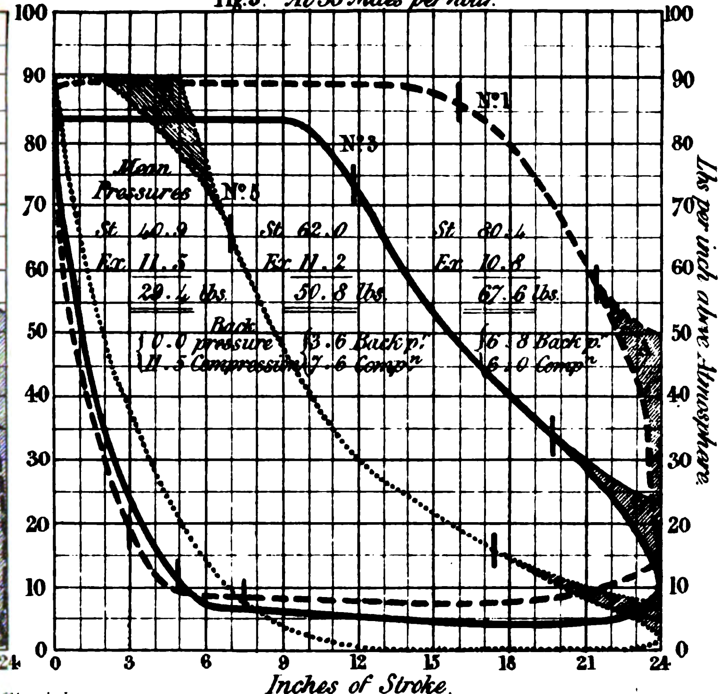


Fig. 5. *At 55 Miles per hour.*



M. Billing, lithog.

Fig. 1.

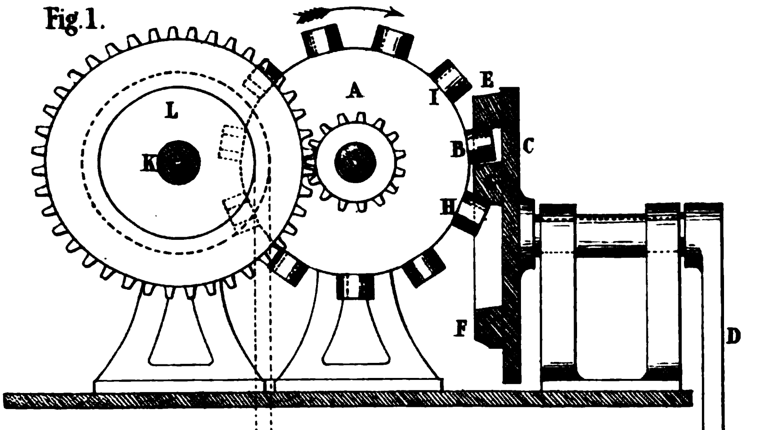
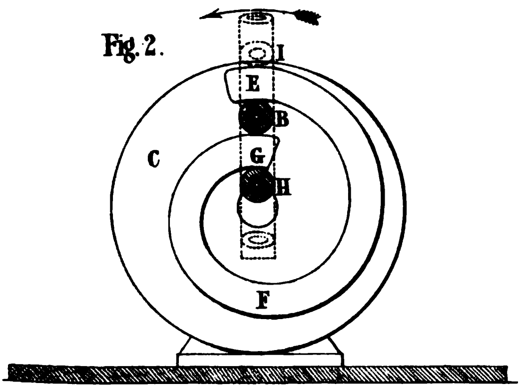


Fig. 2.



Scale 1/4th size

Fig. 3. *Parallel Vice.*

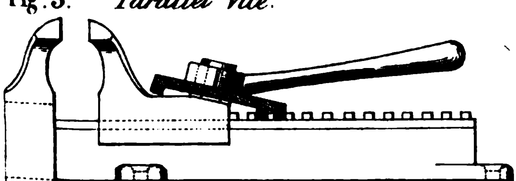
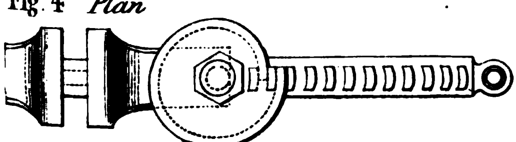
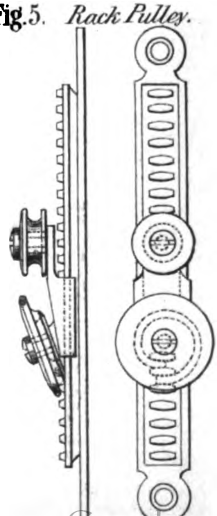


Fig. 4 *Plan*



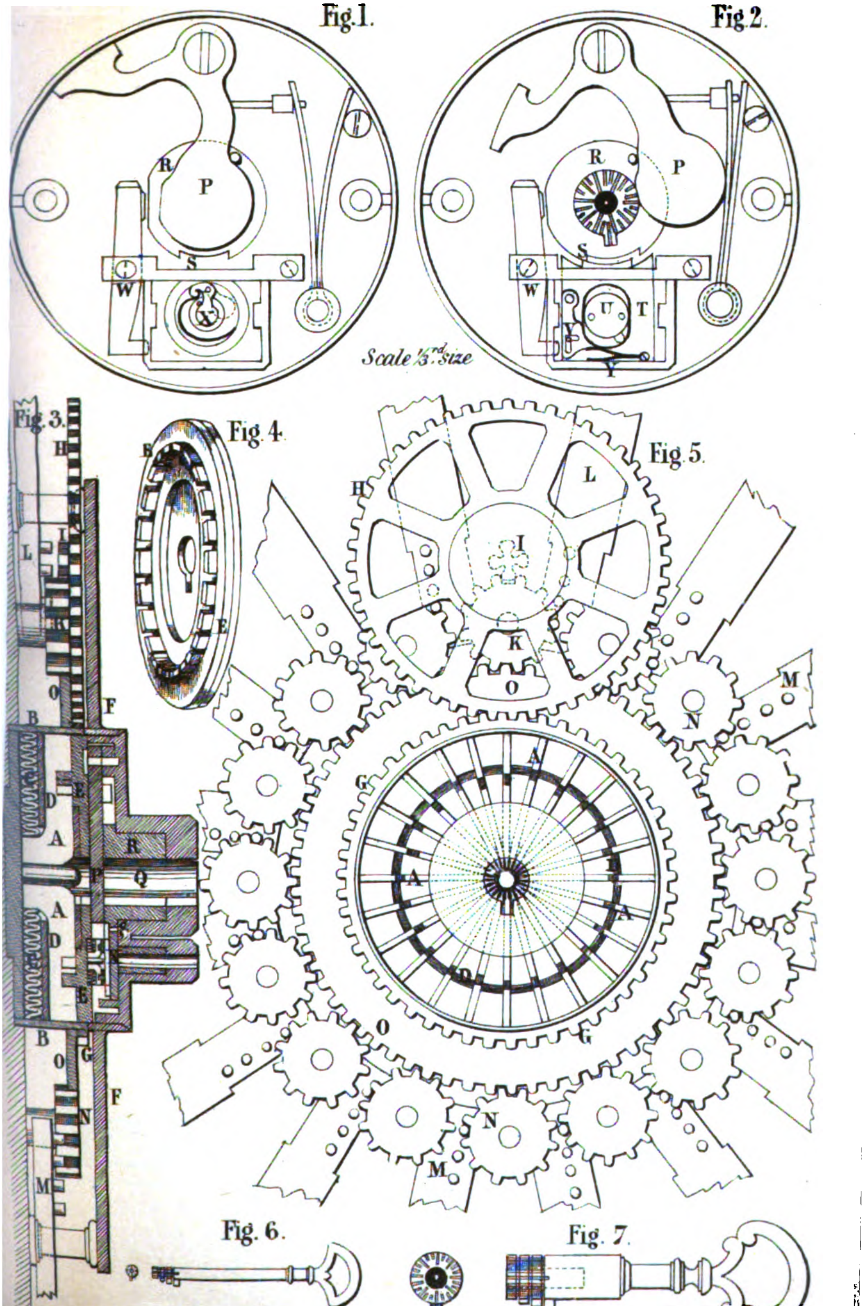
Scale 1/4th size

Fig. 5. *Rack Pulley.*



Scale 1/2 size

COTTERILL'S BANK LOCK.



CENTRIFUGAL PUMP.

Fig. 1.

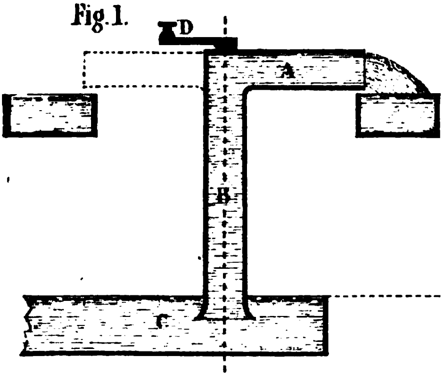


Fig. 2.

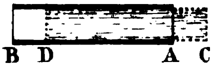


Fig. 3.

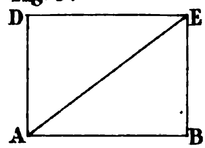
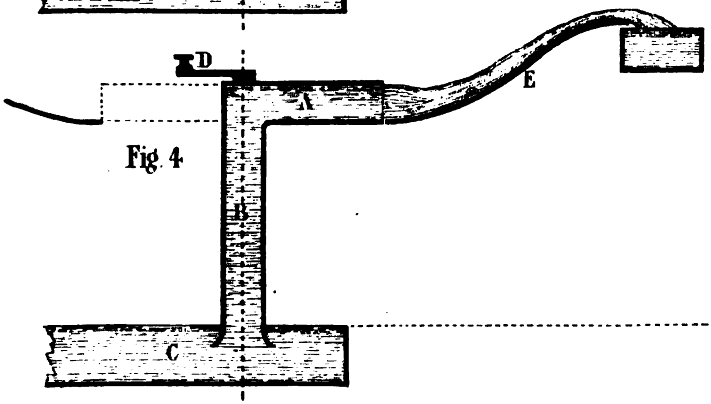
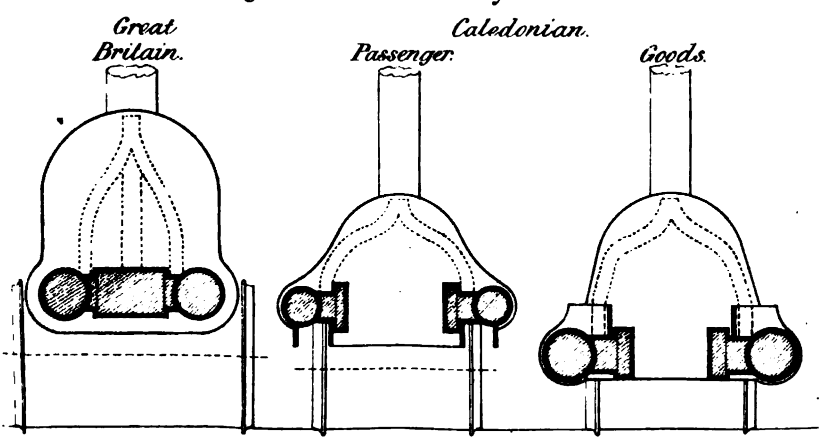


Fig. 4



EXPANSION IN LOCOMOTIVES.

Fig. 5. *Projection of Cylinders.*



Scale 1/80th size

EXPANSION IN LOCOMOTIVES.

Fig. 1. *Indicator Diagrams, at Slow Speed, from Caledonian Engine No. 13.*

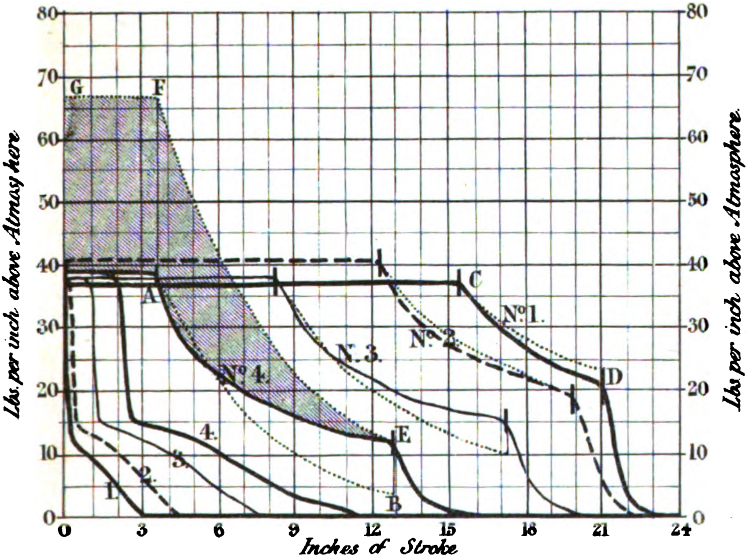
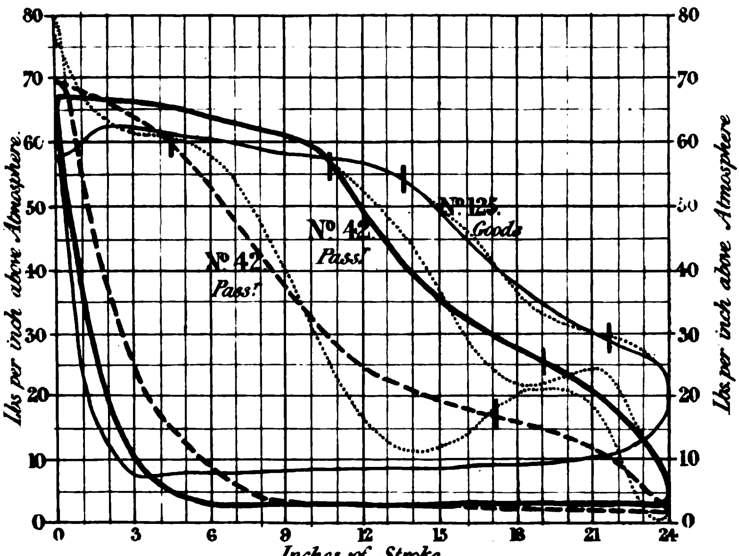
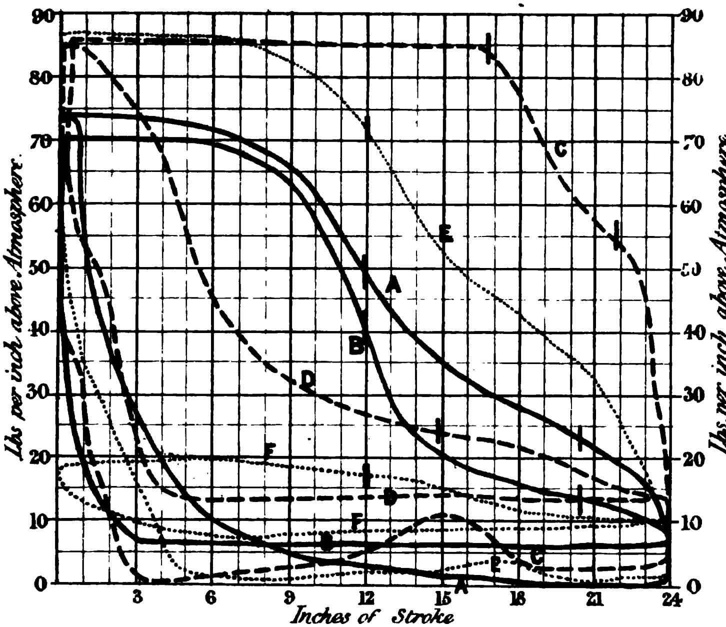


Fig. 2. *Indicator Diagrams at Quick Speed, from Caledonian Engines, Nos. 42 & 125.*



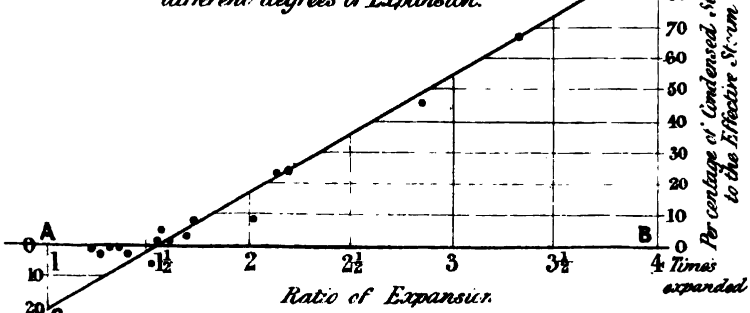
EXPANSION IN LOCOMOTIVES.

Fig. 3. *Indicator Diagrams from Locomotives shewing increase of Back Pressure caused by Water in the Cylinder.*



A	&	B	*Orion Pass.r Engine, 39 Miles per hour.*
C	&	D	*N.o 127 Goods Engine 18 " "*
E	&	F	*D.o D.o 15 " "*

Fig. 4. *Diagram of the Condensation in Outside Cylinder Engines, with the different degrees of Expansion.*



EXPANSION OF STEAM.

Fig 1

Apparatus for Measuring the Total Heat of Steam.

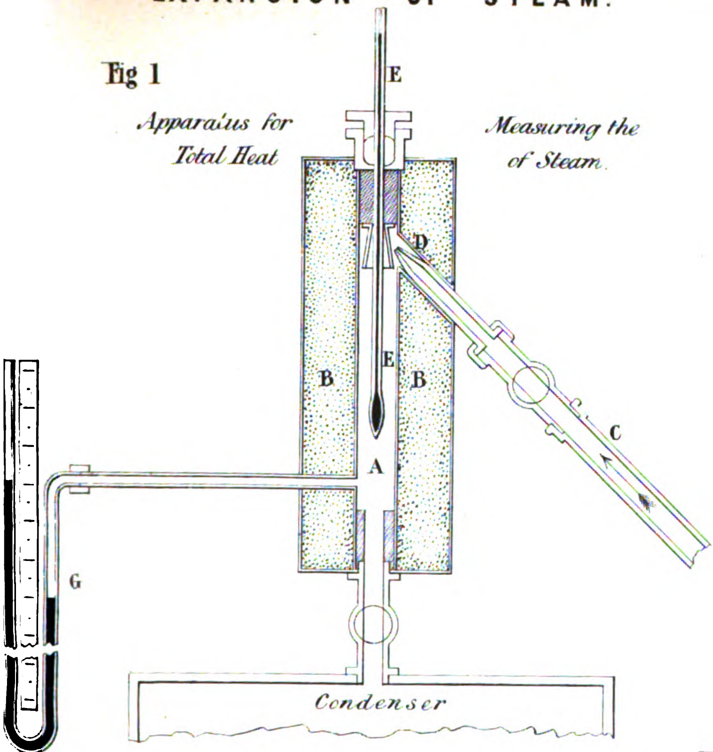
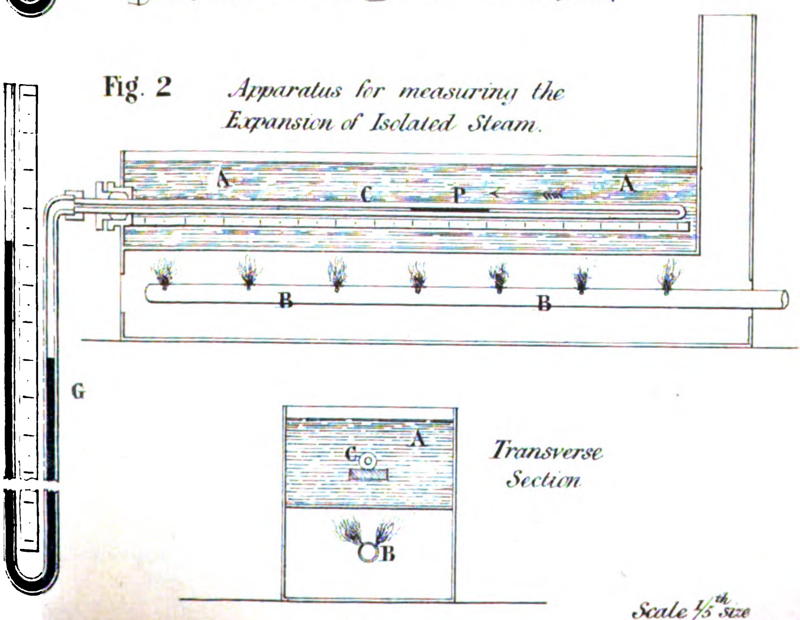


Fig. 2

Apparatus for measuring the Expansion of Isolated Steam.



Scale 1/5th size

EXPANSION OF STEAM.

Fig 1

Apparatus for Measuring the Total Heat of Steam.

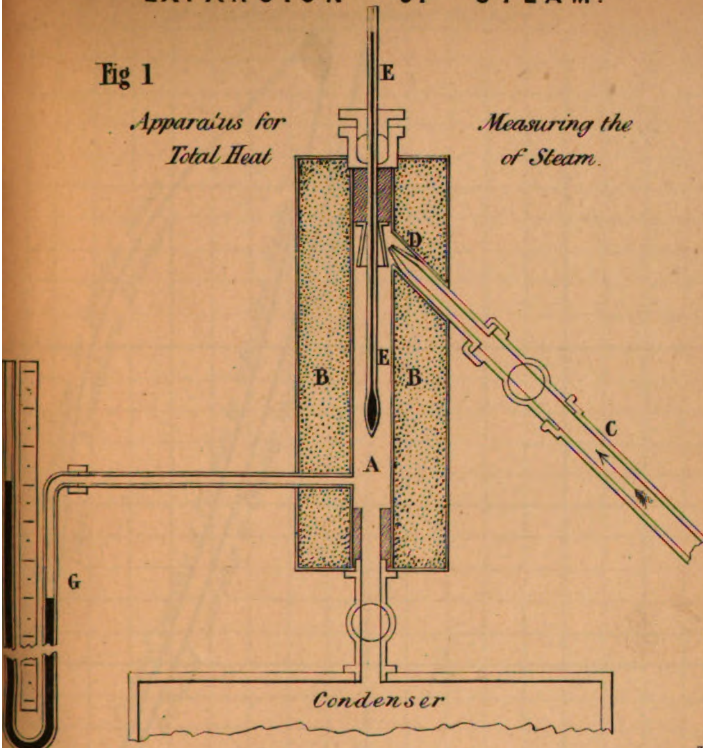
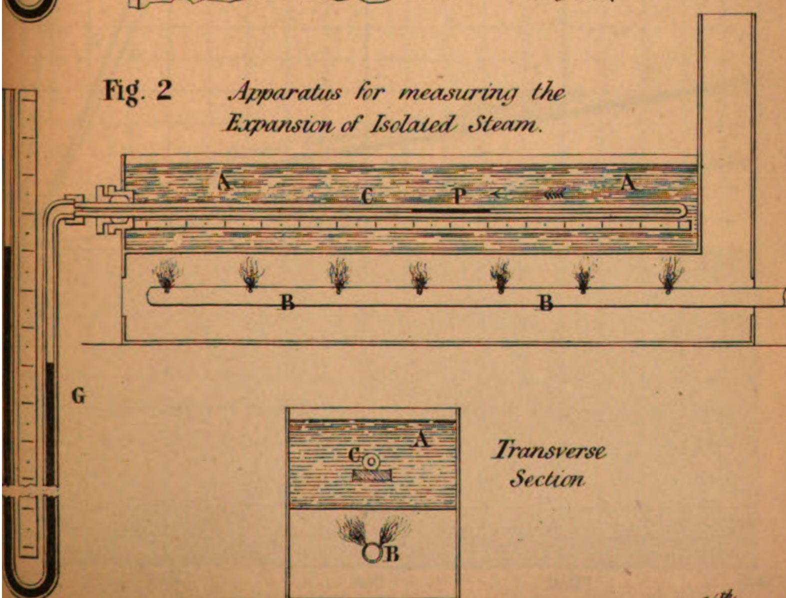


Fig. 2 Apparatus for measuring the Expansion of Isolated Steam.

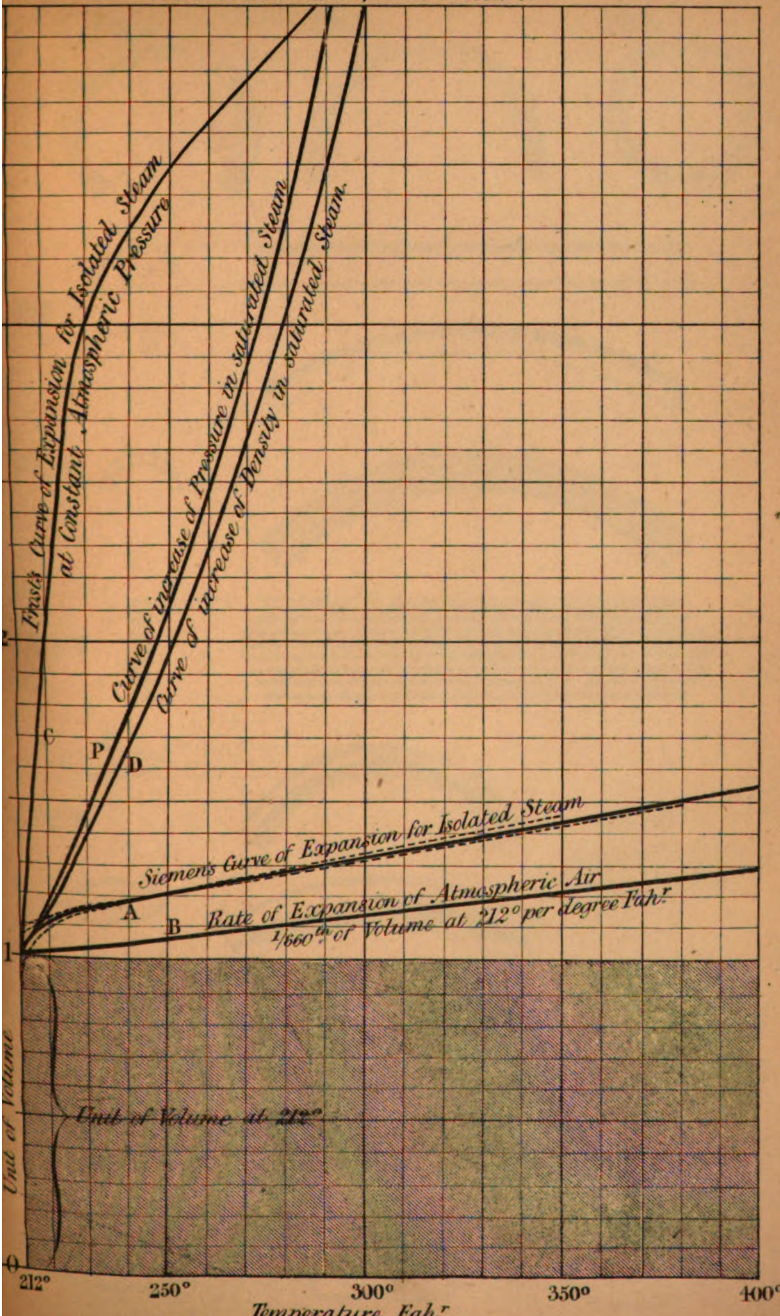


Transverse Section

Scale $1/5^{th}$ size

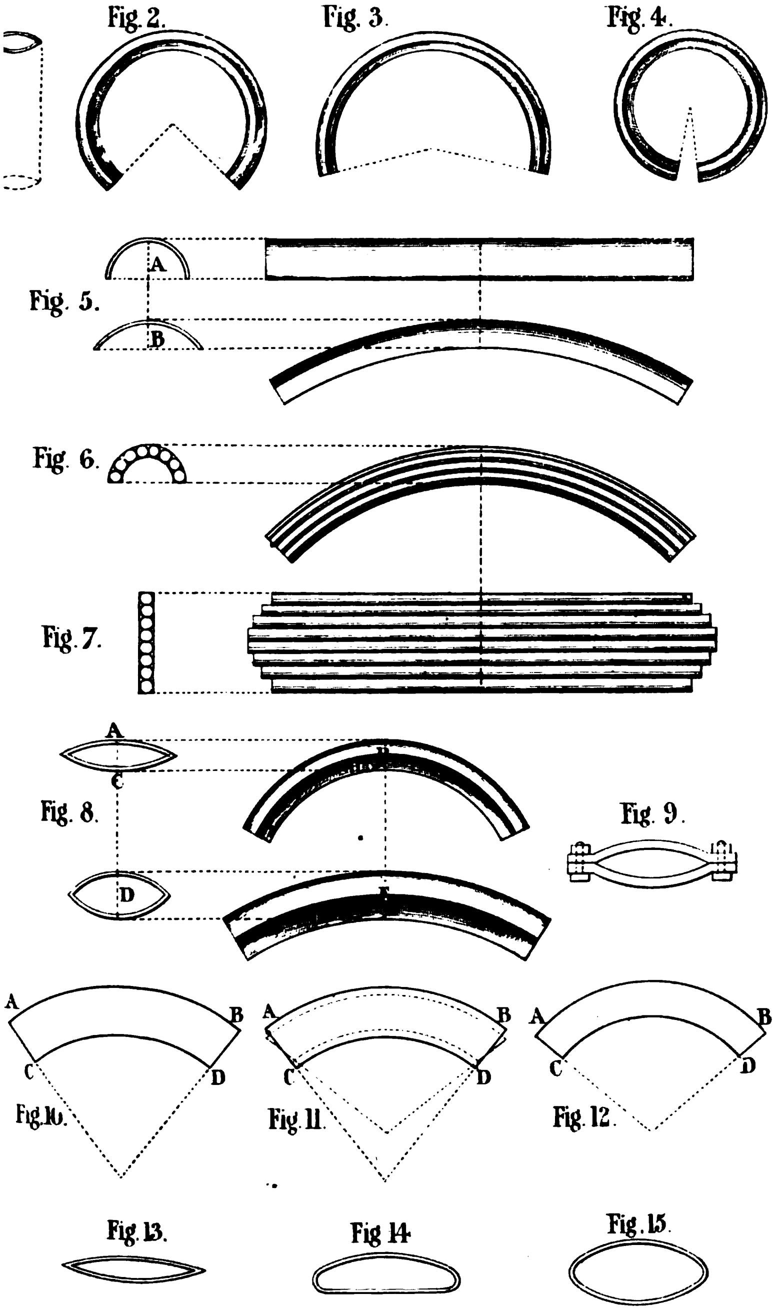
EXPANSION OF STEAM.

Fig. 3. *Expansion of Isolated Steam, by Heat, at Constant Atmospheric Pressure.*



BOURDON'S GAUGES.

Diagrams illustrating the principle of Action.



BOURDON'S GAUGES.

Steam Pressure Gauge

Fig. 16.

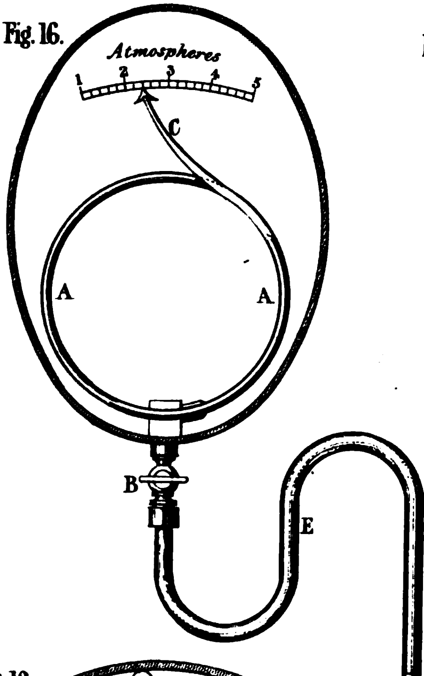


Fig. 17.

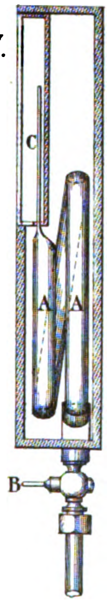


Fig. 18.

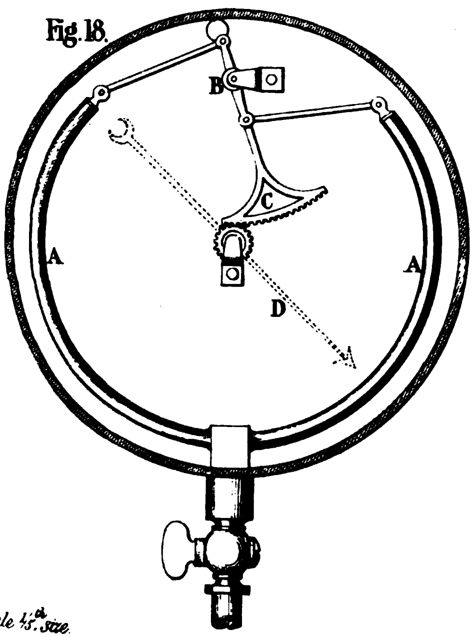
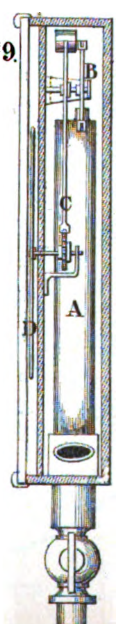


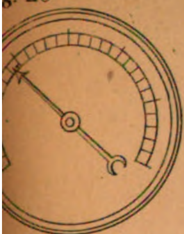
Fig. 19.



Scale 1/5th. size.

BOURDON'S GAUGES.

g. 20



Thermometer.

. 21.

Fig. 23.

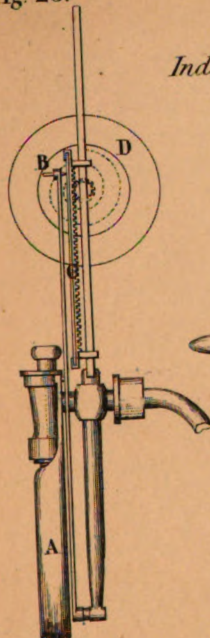
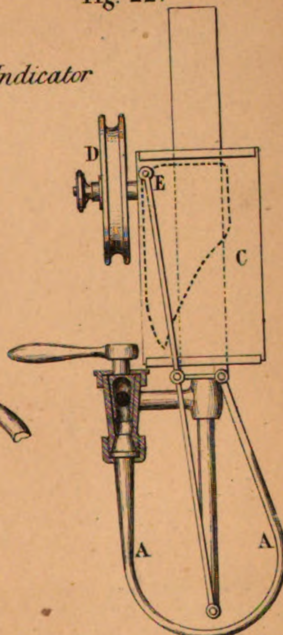


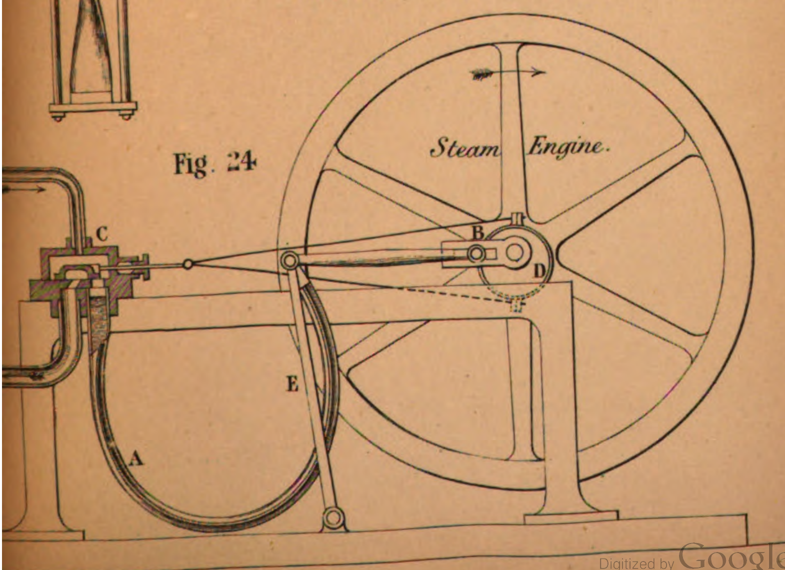
Fig. 22.

Indicator



Scale 1/4th size

Fig. 24



APPOLD'S CENTRIFUGAL PUMP.

Fig. 1.

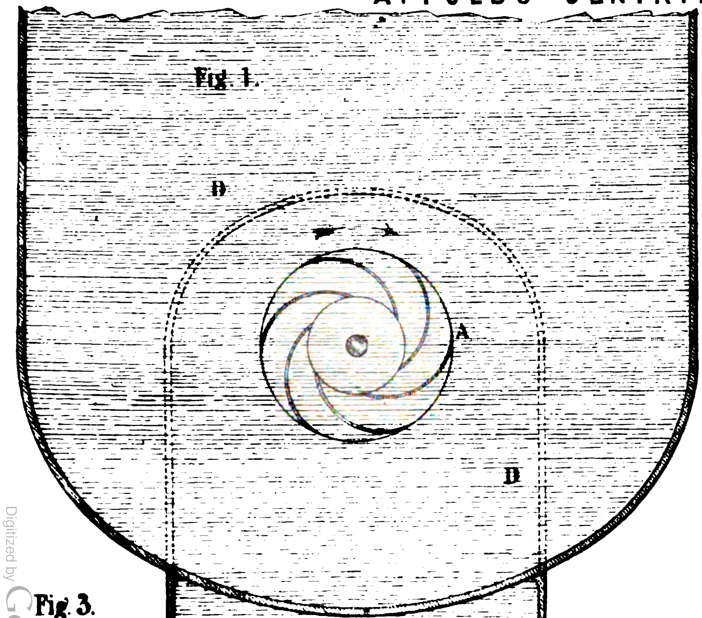


Fig. 2

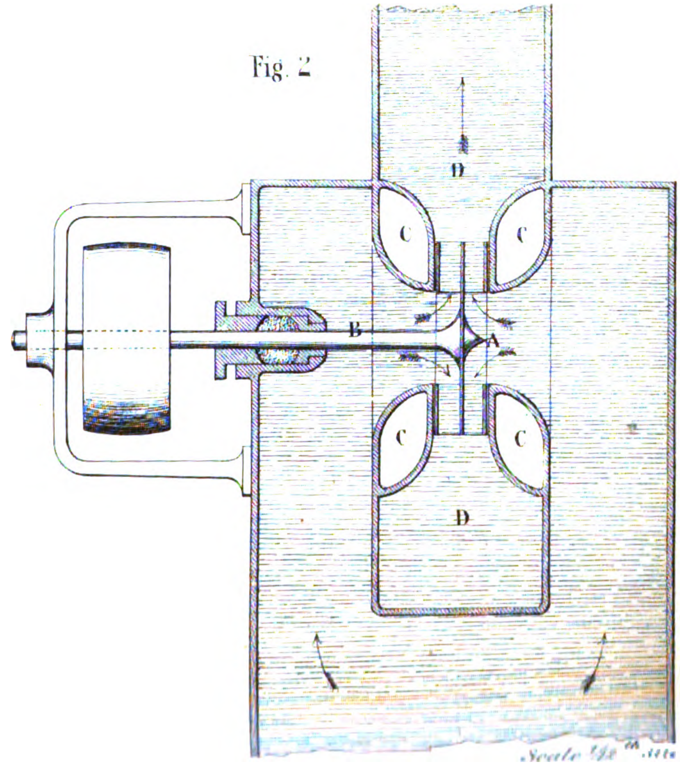
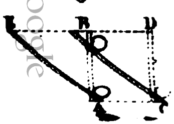


Fig. 3.



CENTRIFUGAL PUMPS.

Plate 69.

Appold's Pump.

Fig. 4.

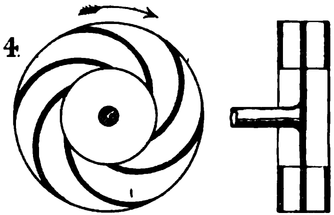


Fig. 5.

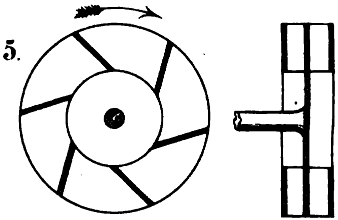
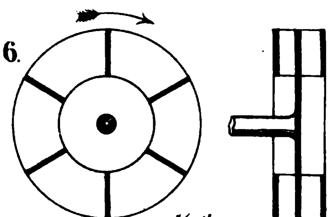


Fig. 6.



1/12th size

Gwynne's Pump.

Fig. 7. *Longitudinal Section.*

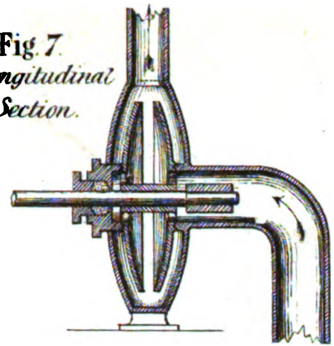
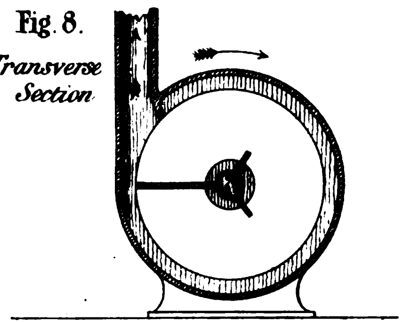


Fig. 8. *Transverse Section.*



1/12th size

Bessemer's Pump.

Fig. 9. *Vertical Section.*

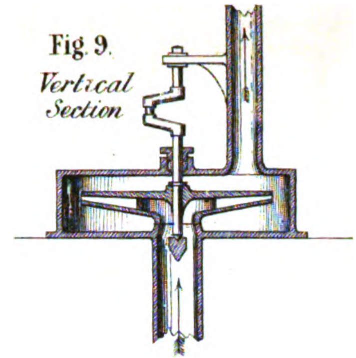
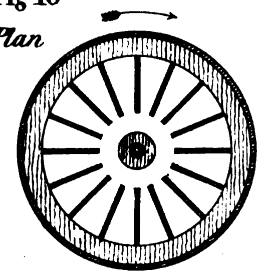


Fig 10 *Plan*



Scale 1/48th size

ORDINARY SCREW PROPELLER.

Plate 70.

Fig. 1.

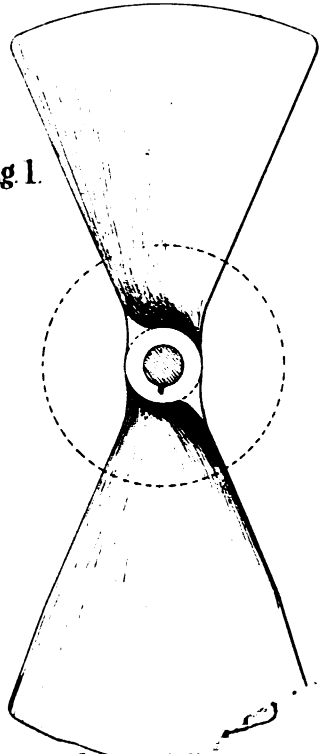


Fig. 2

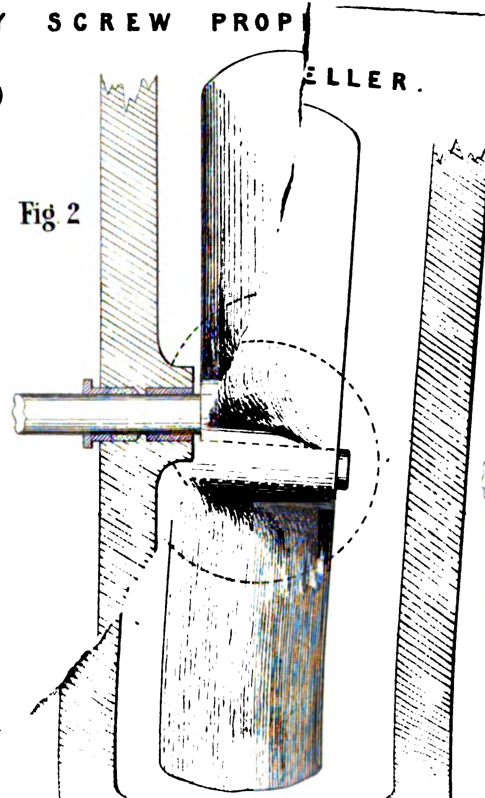


Fig. 3.

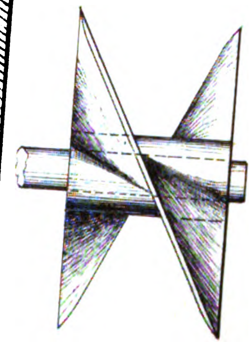
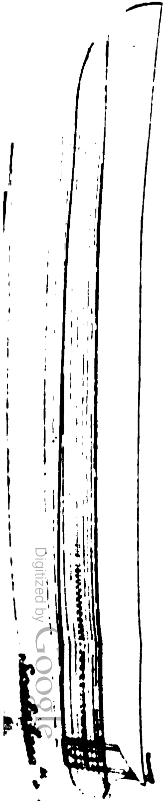


Fig. 4. The "Weaver" Screw Steam Boat.



…ED SCREW PROPELLER.

Plate

Fig. 5.

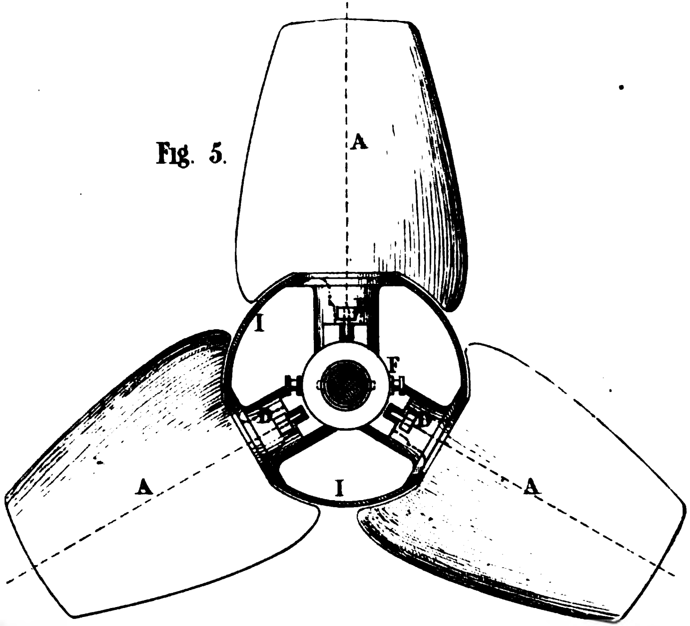


Fig. 6.

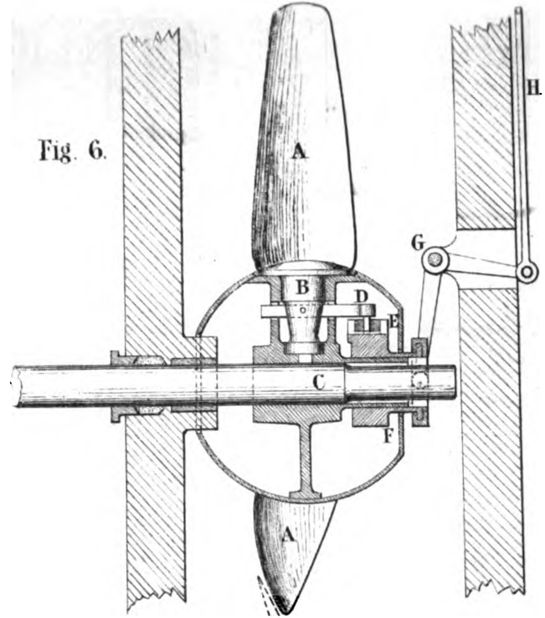
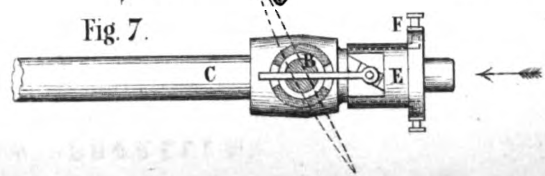
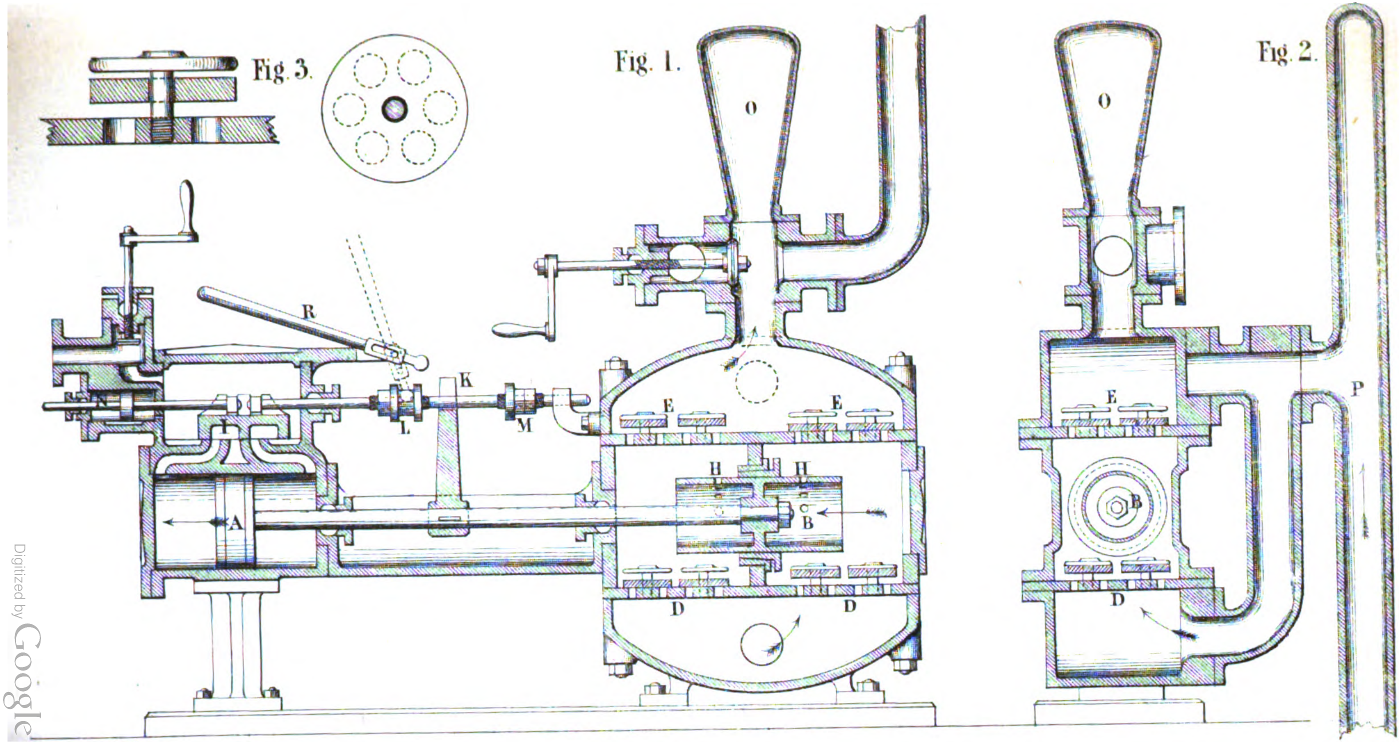


Fig. 7.



Scale 1/18th size

DIRECT-ACTING STEAM PUMP.



ale 1/12th size

Plate 73.

FIRE BRICK GAS RETORTS.

Fig. 1. *Front Elevation.*

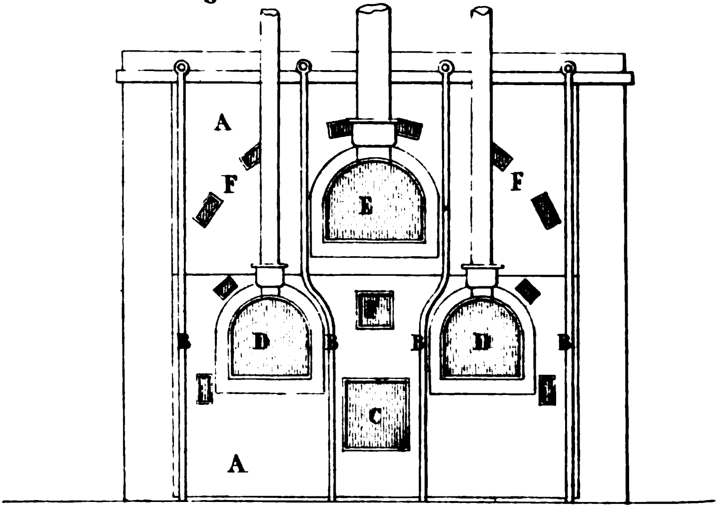


Fig. 3. *Details of Arch Bricks*

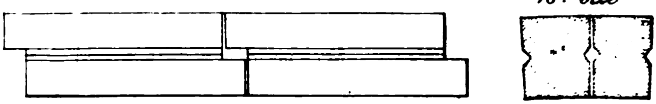
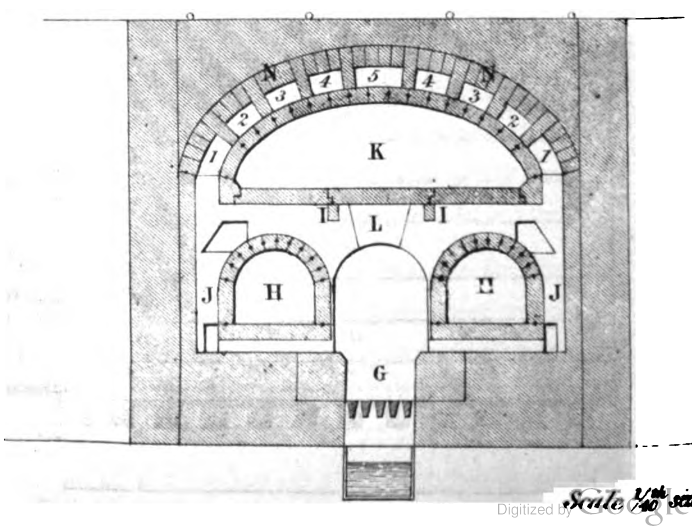


Fig. 2. *Transverse Section.*



Scale 1/40th size

FIRE BRICK GAS RETORTS.

Plate 74.

Fig. 5. *Longitudinal Section*

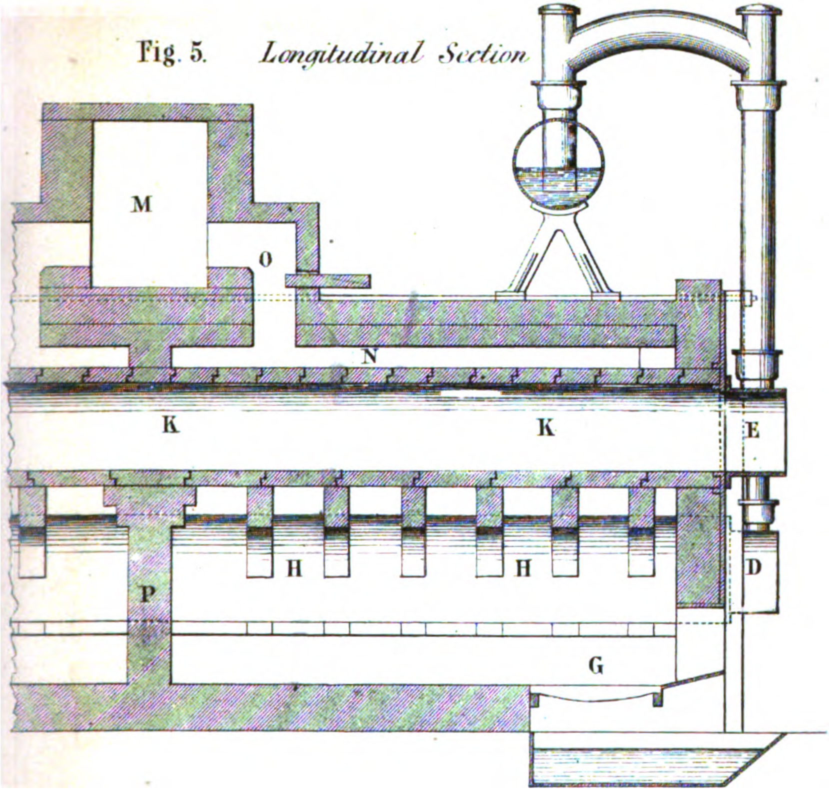
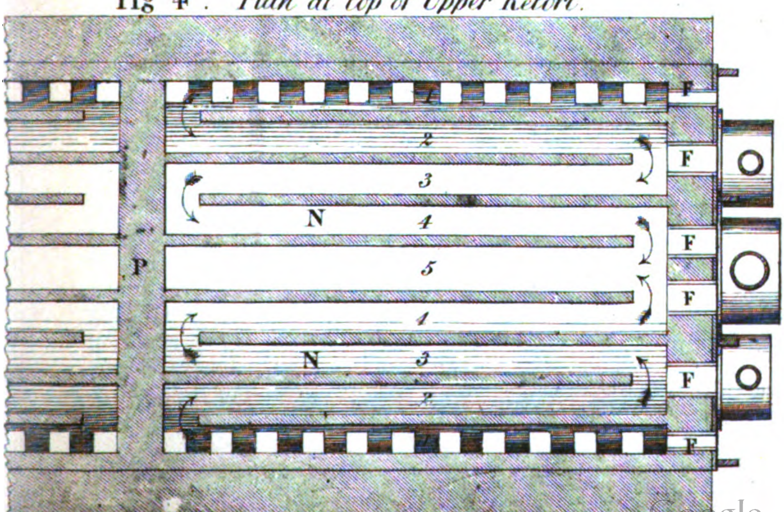


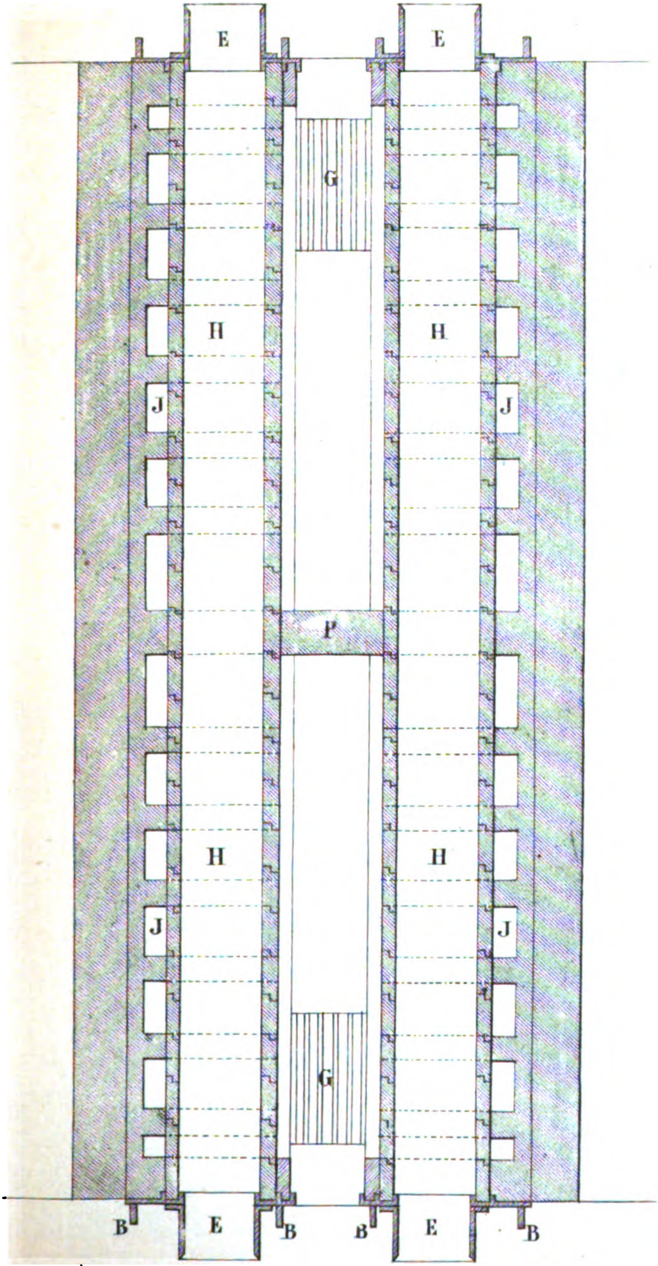
Fig 4. *Plan at top of Upper Retort.*



Scale 1/40th size

FIRE BRICK GAS RETORTS.

Fig. 6. *Plan at centre of Lower Retorts.*



Scale 1/40th size

Apparatus for Collecting the Waste Gases

Fig. 1.

Ebbw Vale South Wales

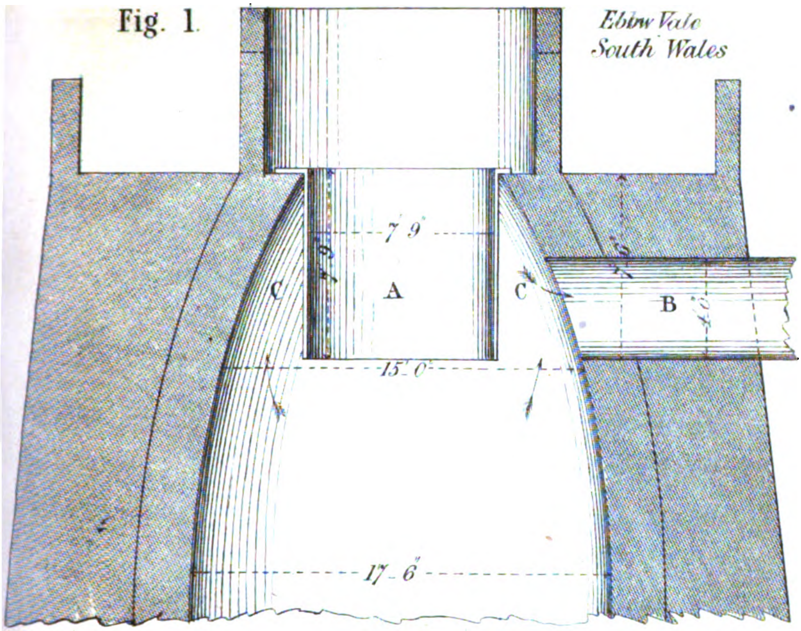
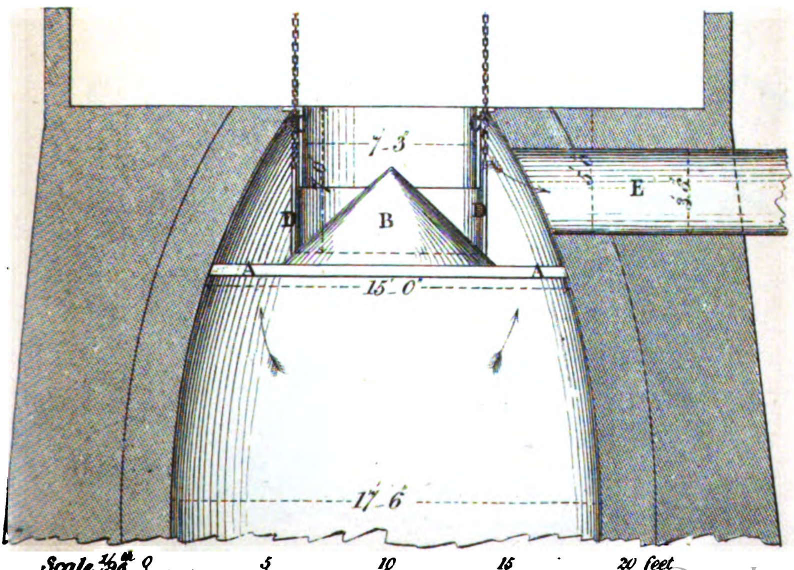


Fig. 2. Cwm Celyn, South Wales



BLAST FURNACES.

Apparatus for Collecting the Waste Gases

Fig. 3. *Ebbw Vale South Wales*

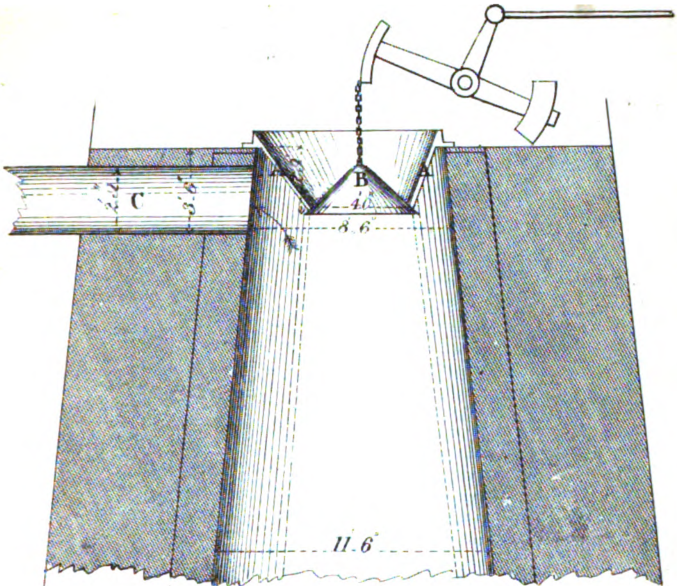
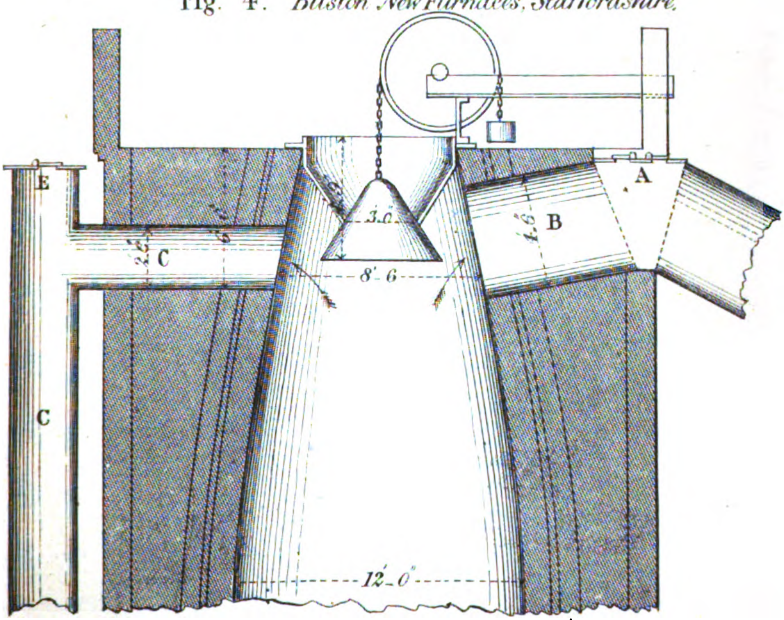


Fig. 4. *Bilston New Furnaces, Staffordshire.*



Scale 1/96th 0 5 10 15 20 feet

Fig. 5.

Dundyvan *Scotland*

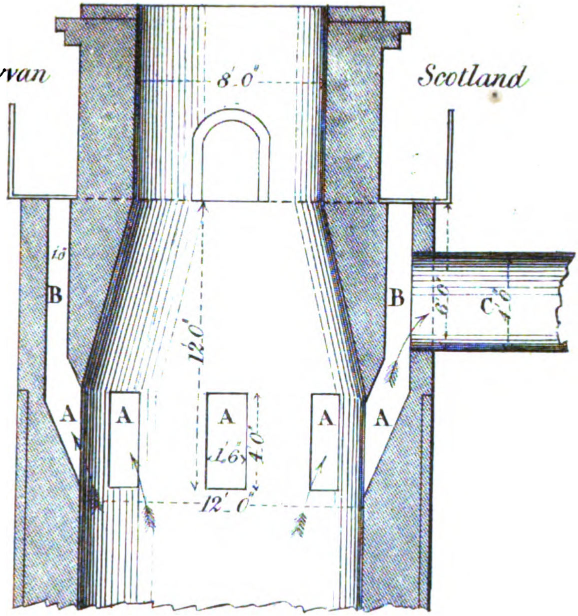
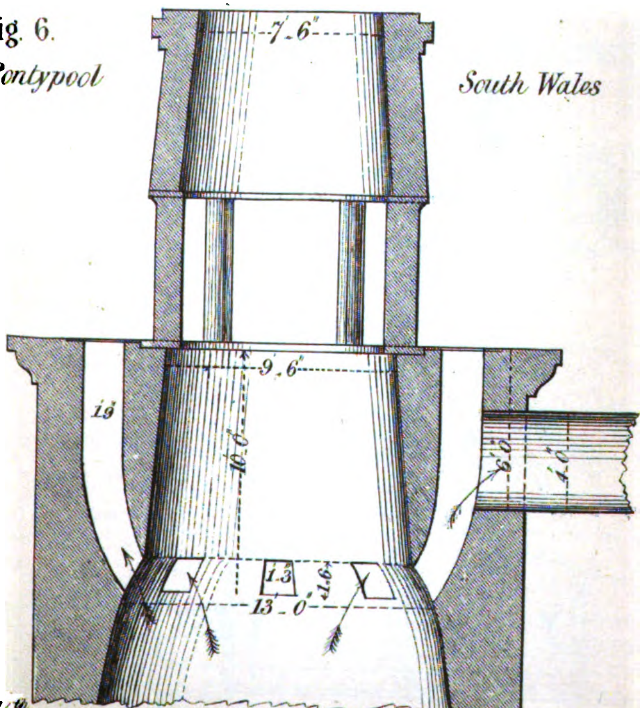


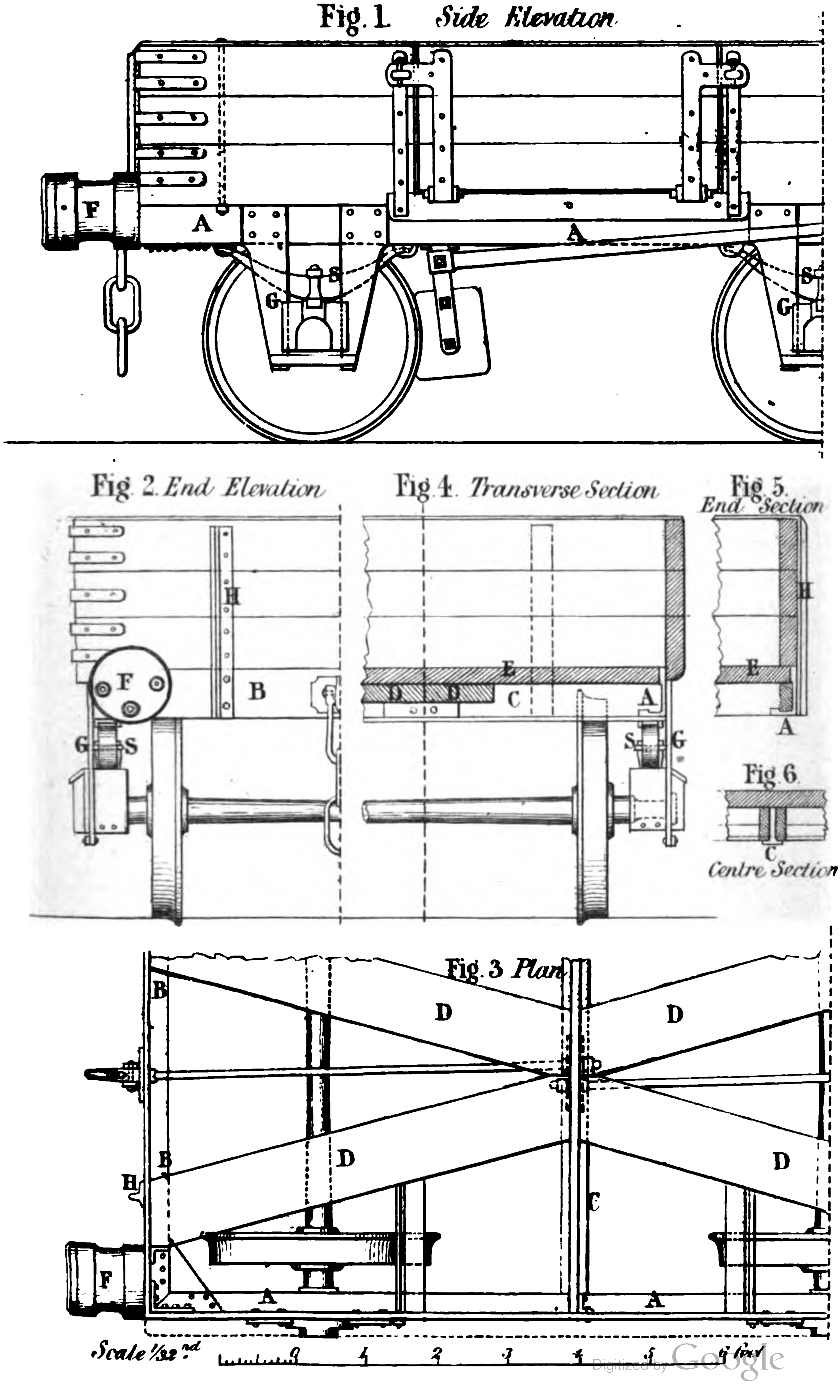
Fig. 6.

Pontypool *South Wales*



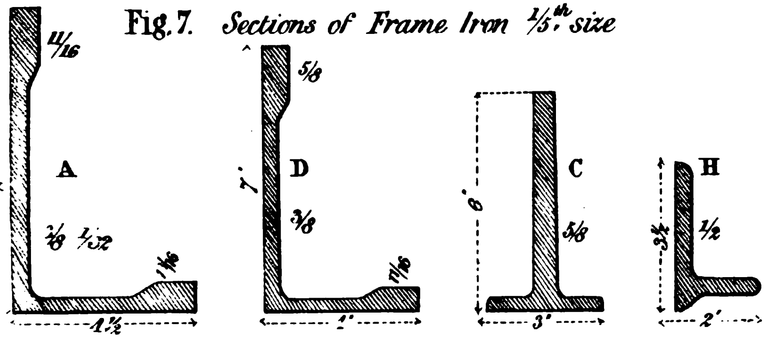
Scale 1/96th 0 5 10 15 20 feet

NEW IRON FRAMED WAGGON.



NEW IRON FRAMED WAGGON

Fig. 7. *Sections of Frame Iron 1/5th size*



ORDINARY WOOD FRAMED WAGGON

Fig. 8. *Side Elevation* · Fig. 9. *Transverse Section*

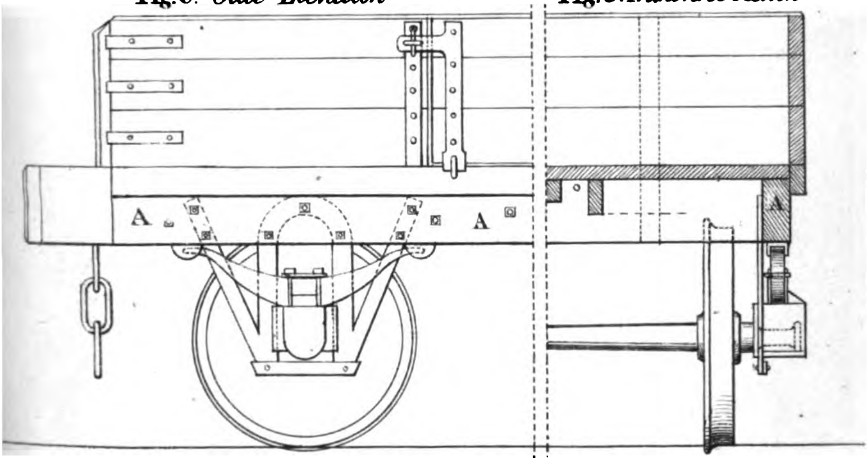
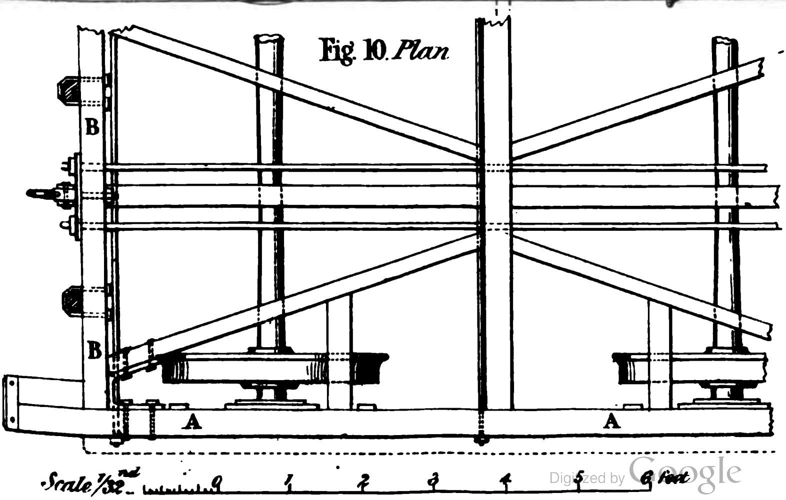


Fig. 10. *Plan*



SELF-LUBRICATING AXLE BOX.

Fig. 1. *Longitudinal Section.*

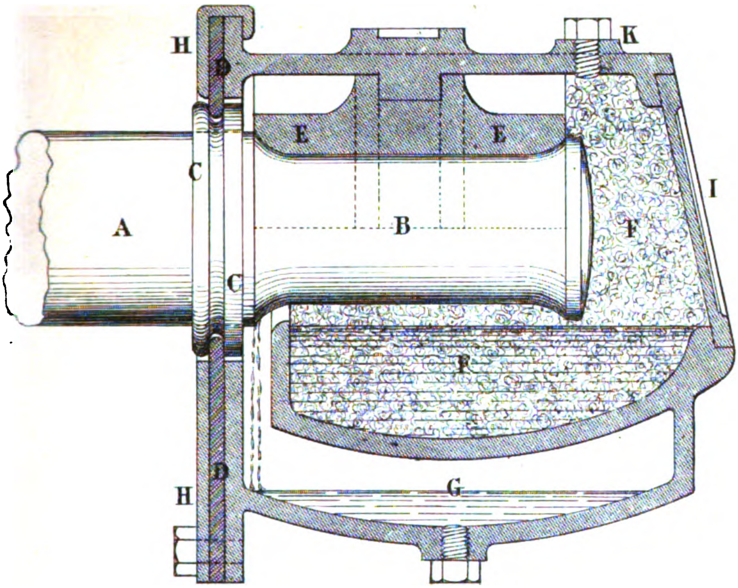


Fig. 2. *Transverse Section.*

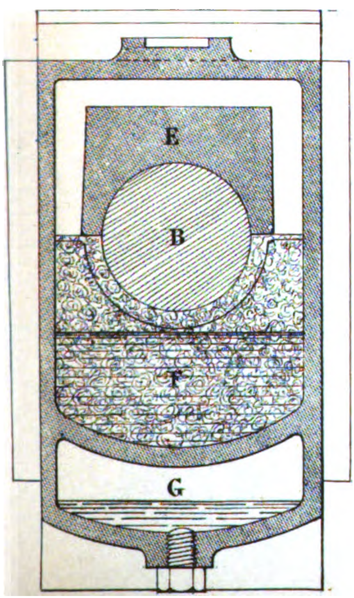
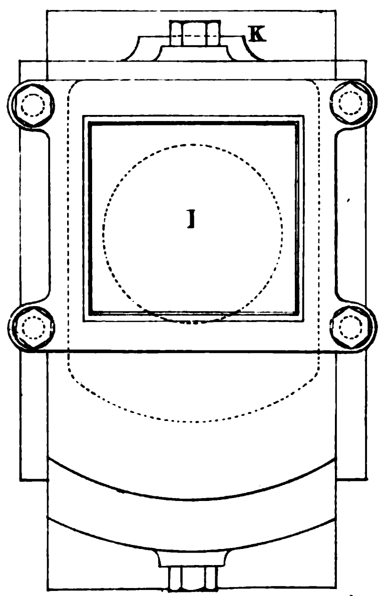


Fig. 3. *Front Elevation.*



Scale ¼th size.

SELF-LUBRICATING AXLE BOX.

Fig. 4. *Back Elevation.*

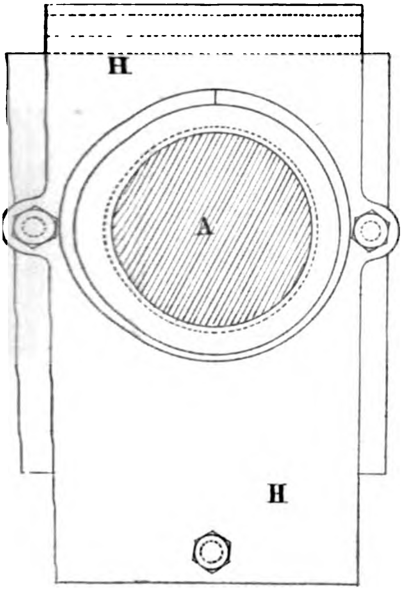
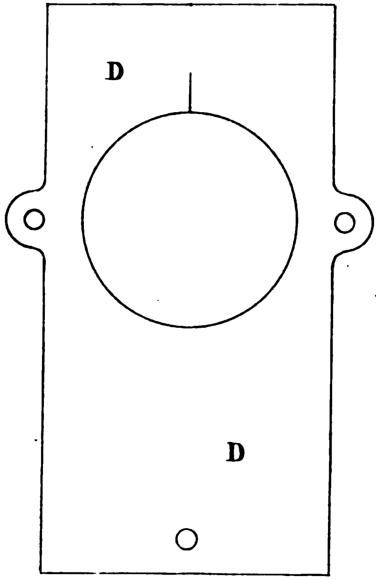


Fig. 5. *Leather Flange.*



Scale ¼th size

AMERICAN SPRING-CROSSING

Fig. 6. *Plan of No. 1 Crossing* *1/12th size*

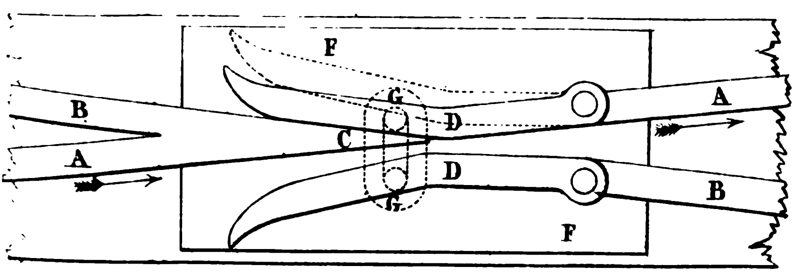
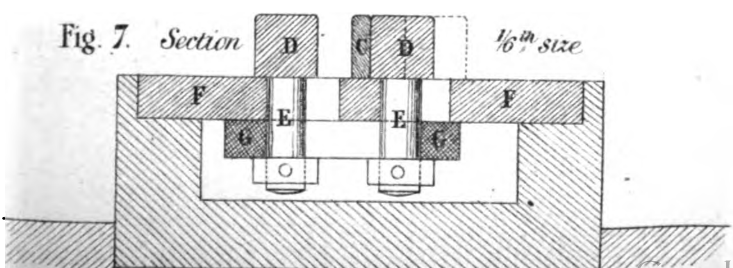


Fig. 7. *Section* *1/6th size*



AMERICAN SPRING CROSSING.

Fig. 8. *Plan of No. 2 Crossing.* $\frac{1}{12}$th size

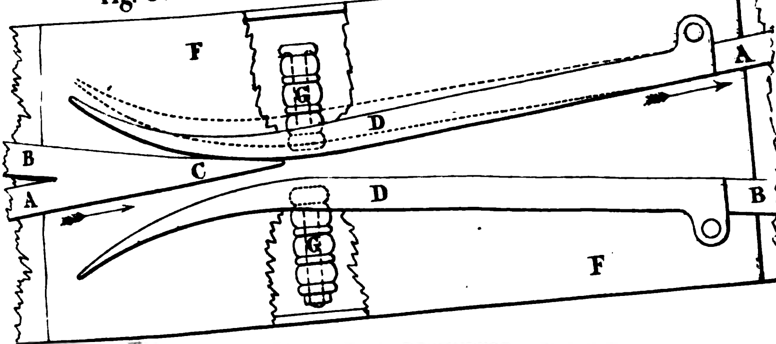


Fig. 9. *Section* $\frac{1}{6}$th size

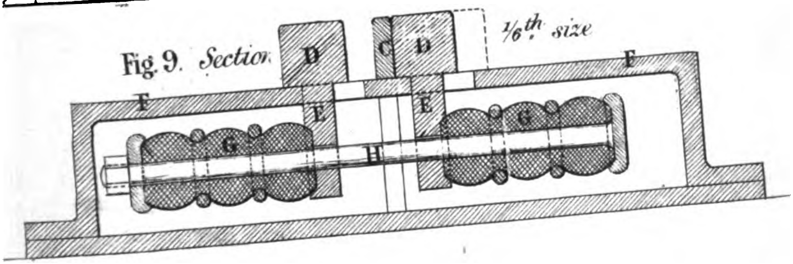


Fig. 10. *Plan of Crossing* $\frac{1}{24}$th size

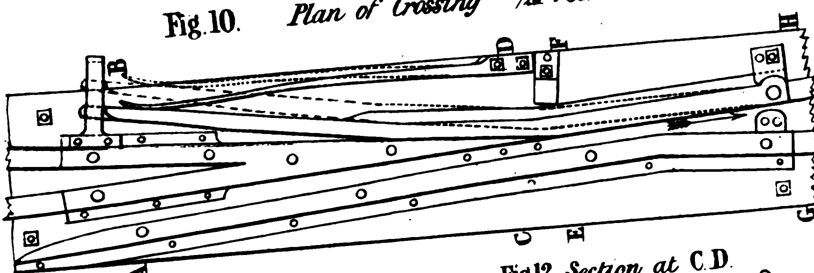


Fig. 11. *Section at* A. B.

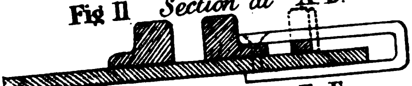


Fig. 12. *Section at* C. D.

Fig. 13. *Section at* E. F.

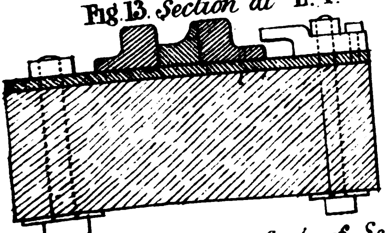
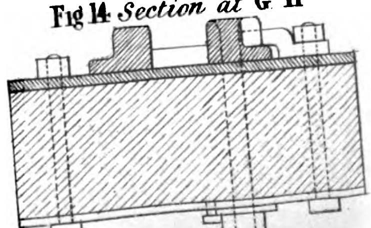


Fig. 14. *Section at* G. H



Scale of Sections $\frac{1}{12}$th size.

INSTITUTION

OF

MECHANICAL ENGINEERS.

PROCEEDINGS.

1853.

PUBLISHED BY THE INSTITUTION,
54, NEWHALL STREET, BIRMINGHAM.

1853.

INDEX.

PROCEEDINGS.

THE SIXTH ANNUAL GENERAL MEETING of the Members was held at the house of the Institution, Newhall Street, Birmingham, on Wednesday, January 26th, 1853, ROBERT STEPHENSON, Esq., M.P., President, in the Chair.

The Minutes of the last General Meeting were read by the Secretary, and were confirmed.

The SECRETARY then read the following

ANNUAL REPORT OF THE COUNCIL,

1853.

THE COUNCIL have the satisfaction of congratulating the Members on this occasion of the Sixth Anniversary of the Institution, upon the advancement and progress of the Institution, and its increasing efficiency and success.

The number of Members, &c., for the last year is 204, of whom 13 are Honorary Members, and 3 are Graduates.

The financial statement of the affairs of the Institution for the year ending 31st December, 1852, shows a balance in the Treasurer's hands of £173 1s. 3d., after the payment of all accounts due to that date. The Finance Committee having examined and checked all the receipts and payments of the Institution for the last year, 1852, have reported that the following balance sheet, rendered by the Treasurer, is correct.

(See Balance Sheet appended.)

The Council have the pleasure of announcing that the following Donations to the Library of the Institution have been received during the past year :—

C. Cowper, on the Great Exhibition Building of 1851, from the Author.

D. K. Clarke, on Railway Machinery; from the Author.

G. D. Dempsey, on the Machinery of the Nineteenth Century: from the Author.

W. Johnson, on the Patent Law Amendment Act; from the Author.

W. Spence, on the Present State of the Law of Patents; from the Author.

Journal of the Society of Arts.

Minutes of Proceedings of the Institution of Civil Engineers

The Artizan Journal; from the Editor.

The Civil Engineer and Architect's Journal; from the Editor.

The London Journal of Arts; from the Editor.

The Mechanics' Magazine; from the Editor.

The Mining Journal; from the Editor.

The Practical Mechanics' Journal; from the Editor.

Engravings of New Express and Luggage Engines; by Mr. J. E. McConnell.

Improved and Ordinary Safety Lamps, and new Carriage Lamp; by Mr. Samuel Thornton.

Busts of the Duke of Wellington and Sir Robert Peel; presented by Mr. Robert Rawlinson.

Bust of Tredgold; presented by Mr. Jonathan D. Ikin.

Bust of Murdoch; presented by Mr. J. E. McConnell.

The Council refer with great satisfaction to the practical value and interest of the Papers that have been presented to the Institution during the last year, and express their thanks to the Authors of the Papers for the valuable information they have furnished to the Institution. The Council confidently anticipate continued advancement in the importance and number of the communications brought before the Institution, and they have promises of several valuable Papers for the ensuing year.

The following Papers have been read at the Meetings in the last year:—

On an Improved Boiler for Marine Engines; by Mr. Andrew Lamb, of Southampton.

On an Improved Break for Railway Carriages, &c.; by Mr. William Handley, of London.

On a Continuous Expansion Steam Engine; by Mr. James Samuel, of London.

On a New Mode of Measuring High Temperatures; by Mr. John Wilson, of St. Helens, Lancashire.

On the Expansive Working of Steam in Locomotives; by Mr. Daniel K. Clark, of Edinburgh.

On a New Portable Lifting Machine; by Mr. J. E. McConnell, of Wolverton.

On the Mathematical Principles Involved in the Centrifugal Pump; by Mr. Andrew J.-Robertson, of London.

On the Expansive Working of Steam in Locomotives; (second paper), by Mr. Daniel K. Clark, of Edinburgh.

On the Expansion of Isolated Steam, and the Total Heat of Steam, by Mr. Charles W. Siemens, of London.

On Bourdon's Metallic Barometer, Indicator, and other Applications of the same principle; by Mr. Charles Cowper, of London.

On a New Improved Screw Propeller; by Mr. George H. Bovill, of London.

On a New Direct-Acting Steam Pump; by Mr. William K. Whytehead, of London.

On Improved Fire-Brick Gas Retorts; by Mr. J. E. Clift, of Birmingham.

On the Arrangement of the Materials in the Blast Furnace, and the Application of the Waste Gases; by Mr. Samuel H. Blackwell, of Dudley.

On Improvements in the Construction and Materials of Railway Waggons; by Mr. William A. Adams, of Birmingham.

On a New Self-lubricating Axle Box for Railway Engines and Carriages; by Mr. Paul R. Hodge, of London.

On a Self-Acting Spring Crossing Point for Railways; by Mr. Paul R. Hodge, of London.

The Council are desirous particularly to call the attention of the Members to the importance of the preparation of Papers on some engineering subjects that have come under their attention, for the purpose of advancing the objects of the Institution, by the communication and interchange of information and experience upon improvements and practical working, and extending the utility of the Institution, in promoting improvements and affording opportunity for carrying out practical investigations and experiments. A list of proposed subjects for Papers is appended, and the Council invite communications from the Members and their friends on these and other subjects that will be serviceable and interesting to the Institution; and they also invite the Members to aid in the formation of the collection of mechanical models and drawings, and books for the library, with indicator-cards from steam engines, and statistical returns of the working of engines, &c., so as to extend the utility of the Institution.

The Officers of the Institution, and five of the Members of the Council in rotation, go out of office this day, according to the rules, and the ballot will be taken at the present Annual Meeting for the election of the Officers and Council for the ensuing year. An increase in the number of Vice-Presidents, from three to six, was proposed at the last meeting of the Institution, to be submitted to the decision of the Members at the present Annual Meeting.

THE CHAIRMAN congratulated the members on the eminent success of the Institution; during the six years since its foundation it had been steadily increasing in prosperity, in the importance of the proceedings, and the number of members.

The transactions during those years showed a list of papers including many important subjects; many of them subjects of great interest, occupying the attention of the profession. Amongst the papers he might allude to two that occurred to him: Mr. Blackwell's, "On Iron Furnaces," and Mr. Clark's, "On Locomotive Engines," which he considered very valuable contributions to this Institution, and to science in general. He hoped the members would keep up well the supply of practical papers; and in addition to such papers, he wished to call the attention of the members to the value and

desirability of supplying to the Institution reports on any successful experiments that came under their attention and experience. He also considered that it would be a great advantage not to confine these reports to successful, but also to report on unsuccessful experiments; the best way to succeed was to be acquainted with the failures that had occurred. Failure implied an erroneous judgment on some one or more points; and well-recorded facts, whether of success or failure, were most valuable, as the means of rectifying and avoiding in future the erroneous judgments that had been previously formed; and he hoped that all the members would not hesitate to report any failures that occurred to themselves, or that came under their observation. He remembered that one of the first mechanical works that had been put into his hands by his father was the "Repertory of Inventions," and he especially explained to him the reasons why he considered different inventions would not answer; more was learned often from failures than from successes.

On the motion of Mr. S. Thornton, seconded by Mr. A. Allan, the Report was received and adopted.

Mr. E. Marshall moved a vote of thanks to the Council and Officers of the Institution, for their services during the past year; the motion was seconded by Mr. R. Williams, and passed.

The Chairman moved, according to the proposal made at the last general meeting, that the number of Vice-Presidents be increased from three to six; and the motion was passed unanimously.

The Chairman then announced that the ballot-papers had been opened by the Committee appointed for the purpose, and the following Officers and Members of Council were duly elected for the ensuing year.

President:

Robert Stephenson, M.P., London.

Vice-Presidents:

Charles Beyer, Manchester.
William Fairbairn, Manchester.
James E. McConnell, Wolverton.
John Penn, London.
Archibald Slate, Dudley.
Joseph Whitworth, Manchester.

Council:

SAMUEL M. BLACKWELL, Dudley.
JOHN E. CLIFT, Birmingham.
BENJAMIN FOTHERGILL, Manchester.
RICHARD PEACOCK, Manchester.
J. SCOTT RUSSELL, London.

Treasurer:

CHARLES GEACH, M.P., Birmingham.

Secretary:

WILLIAM P. MARSHALL, Birmingham.

The CHAIRMAN announced that the following new members were also elected :—

FRANCIS ADKINS, Birmingham.
WILLIAM G. CRAIG, Newport.
EDWARD DUCLOS DE BOUSSOIS, Paris.
GEORGE ENGLAND, London.
JOSEPH FRASER, Berkswell.
HENRY MARTEN, Wolverhampton.
EDWARD J. PAYNE, Birmingham.
JOSEPH P. RONAYNE, Cork.
JOHN ROSS, Birmingham.
EDWARD SLAUGHTER, Bristol.
THOMAS SPENCER, Westbromwich.

The CHAIRMAN observed, that as he had the honour to be re-elected as President of the Institution, he should be happy to serve during the next year; after which time it was proposed that the President should be changed annually, or at least every two years, according to the plan that was now generally adopted, and was found to work most advantageously in other institutions, such as the Geological and the Astronomical Societies, the Institution of Civil Engineers, &c. He was satisfied this change would be conducive to the permanent interests of the Institution; but in any case, whether in or out of office, he should have great pleasure in testifying the interest that he felt in the Institution, by doing all in his power to promote its welfare, and advance its objects.

The following paper, by Mr. John McConochie, of Wednesbury, was then read :—

ON AN IMPROVED RAILWAY CHAIR.

The consideration of the best means of increasing the durability of that part of the permanent way of railways which consists of its Rails and Chairs, has received much attention of late from practical engineers, the subject having been brought more prominently into notice by the wear and tear, or destruction that takes place in this portion of railway plant; the double-headed rails becoming in some places unfit for use within five or six years from the time they are laid down. The cause of their so soon becoming deteriorated seems mainly to arise from the insufficiency of the common description of Chair. This insufficiency is clearly proved by the thousands of tons of rails that are now being returned into different works as old iron, the bottom head being almost as sound as when rolled, except having indentations every three feet where the Chairs have been fixed; the rails being thus so much damaged as to be unfit for reversing, according to the original intention. Such being the case, it proves the importance of using some description of Chair which will support and secure the rail without injury to its durability.

The subject of the present Paper is an improved Railway Chair, which it is believed will meet this requirement, and increase the durability of the rails from 25 to 50 per cent.

Figs. 1, 2, 3, 4, and 5, Plate 1, represent this improved Chair, as supplied to the Liverpool, Crosby, and Southport Railway. These views show the nature and object of the Chair; it consists of two parts, first, the body of the Chair A, and secondly, the abutment-piece B; the key C is made of either wood or iron, but the former is preferred; a space D, of about 1-8th of an inch is left between the lower head of the rail and the sole of the chair; the fillet E fits loosely into the groove cast in the abutment-piece, which prevents the possibility of its being driven out of the Chair. The weight of the Joint Chair here shown is 35lbs., and the weight of intermediate Chairs for the same section of rail averages 26lbs., which is not more than the weight of the ordinary

description. When it is desirable to remove the rails, the operation is as follows:—the lock key C is driven out, which allows the rail to rise vertically out of the Chair, carrying with it the abutment-piece, so that the operation of turning the rail is performed as easily as when the common description of Chair is used. In the latter the support of the rail is entirely dependent on the wooden key, whereas the improved Chair forms of itself a self-acting fastening for the rails, thereby offering considerable facilities for laying in, repairing, or relaying the road. Besides, as trains may pass over them immediately the rail is laid-in, before keying up, it shows the comparative unimportant office the wooden key has to perform in these Chairs, in comparison with those in ordinary Chairs. In the latter the keys require continual replacing and supervision, which forms a considerable item in the maintenance, both in superintendence and materials; in the improved Chair the office of the wooden key is simply to lock the rail in the Chair, thus forming a more complete bond between the rail and the sleeper.

It may be observed at the same time, that several of these Chairs have now been in use three or four months without any keys; the lateral force of the abutment-piece serving to some extent as a key to them. This point of superiority of the improved Chair over those in common use should not be overlooked, for if the keys in the latter are omitted or get loose and work out, it is to the peril of the trains that pass over them; while in the new Chair it has been proved that such an omission is not attended with any danger, except under extraordinary circumstances, where there may be a liability of the earthwork slipping.

That this improved Chair adds to the stability of the road and stiffens the rail, is proved by the experiments which are appended to this Paper.

The prominent feature in the improved Chair consists in its preserving the lower head of the rail from injury, while the upper one is in use, by supporting the rail as shown in the drawing. The object being to obtain the maximum amount of wear out of a given quantity of material, by wearing down successively the top and bottom surfaces of the rails.

The durability of the rails greatly depends on the strength and steadiness of the fastenings, which is one of the advantages of this Chair, from the fact of downward pressure tending to tighten its hold on the rail: this is an important point, as theoretically, Chairs to be perfect should be as tight to the rails as if they formed a part of them. The fact of the ordinary Chairs being an inefficient fastening, has led to the abandonment in many instances of the double-headed section of rail, notwithstanding its many advantages when used in combination with transverse sleepers. In the opinion of the writer, by the adoption of the present method of fishing at the joints, combined with better intermediate fastenings than the ordinary Chair, the double-headed rail and transverse sleeper cannot fail to outlive all the expedients which have been resorted to of late years to supersede this construction of permanent way, which is common to the Northern Districts, the fatherland of railways.

The ordinary fastenings are loosened and deteriorated principally by the alternate upward, downward, and lateral pressure, from the deflexion of the rails between the supports. In the improved Chair, the combined action of the lock-key and abutment-piece prevents this injurious action going on, as in the ordinary Chair, in the comparative ratios (as shown in the experiment) of from 50 to 100 per cent., according to the different weights applied.

With the ordinary Chair, the tendency of the rail to get bent and crooked operates very materially to lessen its durability; for in some instances, even if the lower head were not notched, it would not be fit to reverse unless straightened, and the fibres consequently disturbed, &c.; but with the improved Chair the liability to get bent is greatly lessened by the additional stiffness these Chairs give to the rail.

With the view of securing a more uniform road, and preventing the possibility of the Joint Chair canting, it is recommended that a sleeper be laid lengthways underneath the Joint Chair, as shown at AA in Figs. 13 and 14, Plate 3.

Another modification of the improved Chair is shown in Fig. 8, Plate 1. It presents more bearing surface to the rail than any other Joint Chair in use, consequently it greatly strengthens the

rail at the joint. It differs from the Chair already described, in having two abutment-pieces instead of one, which are made fast by wrought-iron keys, as shown at I I: when the keys are backed, the rail can be lifted vertically out of the Chair.

The results of some experiments made some time back, by Mr. James Samuel, upon the rails of the Eastern Counties Railway, by interposing gold-leaf between the rail and the chair, showed that the amount of surface in contact between the rail and their ordinary intermediate Chairs was 1½ sq. inches. This appears a liberal calculation, but if we take it as an approximation, it gives a result of rather more than 6 to 1 in favour of the improved Chair; for as the two jaws of the Chair are equal unitedly to 12 inches in length, and as the width of their contact with the neck of the rail may be taken at ¾ of an inch, the total bearing surface is 9 square inches, instead of 1½ inches. Therefore if we take the weight of an engine driving wheel, hammering along at the rate of 30 or 40 miles an hour, to be equal to a force of nine tons, this would throw a pressure of 6 tons on the square inch on the 1½ square inch of rail in contact with the sole of the common Chair; but it would only amount to 1¼ tons per square inch on the underside of the head of the rail in the improved Chair; so that, while the former pressure is sufficient to indent the rail, the latter will probably prove quite harmless.

Objections have been raised to this Chair on the ground that the tendency of the jaws will be to tear the head off the rail. This would be the case if the jaws were tapered to an edge, instead of being rounded to the same curve as the underside of the head of the rail, the part in contact with it. With an edge they would by degrees work their way into the head of the rail, until, lamination taking place, a separation of the top from the bottom part of the rail would ensue. The writer understands that something of this sort took place on the London and Birmingham Railway with some of the first Chairs laid down on that line. In these Chairs a portion of the weight was carried on the sole of the Chair, as in ordinary Chairs at the present time, but in order to give greater support to the rail, the arm of the Chair opposite the key bore right against the head of the rail; it was found, however, that as soon as the under head began to bed into the Chair, the whole of the weight came on the top

of the arm or side of the Chair, against which arm it was backed up, though inefficiently, by the key on the other side of it, but the Chair being only the same width as the common one, did not present much bearing surface to the rail; the weight then bearing on such a narrow surface caused the head of the rail to be indented and injured, and, consequently, the attempt to support the rail at these two points at the same time was abandoned. The failure of these Chairs, however, cannot be taken as an argument against the success of this improved description. For example, a strong pair of shears, while its edges are square and sharp, will cut through the thickest boiler-plate; to this the Chairs just alluded to, which injured the rails, may be compared; but if the cutting edges of those shears were rounded, and the surface increased, then the strongest machine that was ever yet constructed for shearing would be unable to effect an incision; in like manner the improved Chairs, with their edges rounded to the curve of the rail, and extended longitudinally (as shown in the drawings) would be unable to cut, but merely hold the rail secure.

The following are the principal advantages of this Chair:—

1st.—The lower head of the rail is preserved free from injury, while the upper one is in use.

2nd.—The abutment-piece, or loose jaw, forms a self-acting fastening.

3rd.—The Improved Chair gives the rail great additional stiffness, vertically and laterally.

4th.—The length of the jaws of the Chairs causes the distance of unsupported rail between Chairs placed the usual distance apart to be less than with those in ordinary use.

5th.—This Chair, by preventing the ends of the rails lipping, and securing level joints, lessens the wear and tear of the rolling stock, and promotes ease in travelling.

6th.—The keys require much less attention, as their office is not to support the rail, as in the common Chair, but only to keep it from rising in the Chair.

7th.—The above advantages are secured at a very slight extra expense on the first cost of the chair.

In conclusion it may be stated, that the Engineers who have adopted the improved Chair, admit that the advantages here enumerated are so far fully borne out in practice.

The following experiments were made with Mr. Marshall on these chairs:—

First Experiment.

The rail experimented upon was the same section as used on the Liverpool, Crosby, and Southport Railway, viz., 5 inches deep and $2\frac{1}{8}$ inches broad in the head, by $\frac{5}{8}$ inch thick in the web, and 72lbs. per yard. One of these rails being placed in one of the improved Chairs, as shown in Fig. 9, Plate 2, downward pressure was applied by the hydraulic ram H, at the points A B, until the end of the abutment-piece in the Chair cracked at C, through the deflection of the rail; the rail being taken out, the permanent deflection was $\frac{5}{8}$ of an inch in the 3 feet between the centre of the supports A and B. The pressure when the end of the abutment-piece cracked was nearly 40 tons. While the rail was deflecting the motion of the scale upon the surface of the rail was very conspicuous. The amount of deflection of the rail was the entire cause of the fracture of the abutment-piece.

Second Experiment.

The pressure was applied on a joint Chair, and two intermediate Chairs, as shown in Fig. 10. The same experiment was then tried with common Chairs instead of the improved Chairs, a line being drawn across in each case to gauge the deflection at D and E.

The results are shown in the following table:—

TABLE OF EXPERIMENTS ON DEFLECTION OF RAIL.

Pressure.	Deflection with Improved Chair.	Deflection with Ordinary Chair.
Tons.	Inches.	Inches.
15	—	—
20	—	—
31	·01 (about)	·02 (about)
40	·07	·12
50	·12	·16
60	·14	·19
70	·16	·25

At 40 tons pressure one of the outside Chairs broke across the sole, but another being substituted for it, the experiment proceeded

without interruption, the result obtained being as stated above. The lateral deflection in each case was as shown in Fig. 12, when examined after the experiment, being one-half less with the improved than with the ordinary Chairs. These results were unexpectedly satisfactory, proving the superiority of the new Chair over those in common use, by its adding to the stiffness of the rail, and increasing its capability to sustain weight. This may be accounted for by the improved Chair holding the rails much tighter than the common Chair; the side pressure of the abutment-pieces having the effect of tightening the rails in their Chairs in proportion to the pressure applied, but with the common Chair the effect of the pressure being to loosen the rails in the Chairs.

It is a well-known fact with respect to girders, that if two are made precisely alike in all particulars, and fixed in a building, the one with its ends made tight in the walls, while the ends of the other are left loose, merely resting on the wall, then if the latter one is weighted till it breaks, the same weights may be placed on the former one with impunity, without any fracture taking place. From a similar reason the new Chairs add to the stiffness of the rails, and preserve them from deflecting *laterally* and vertically to the extent they do in the common Chairs. The object of the next and last experiment was to test the strength of the Chair. The rail was put in an intermediate Chair, and the pressure applied, as shown in the sketch, Fig. 11. When the pressure reached 60 tons, the rail broke through in the centre of the Chair, cracking off simultaneously the ends of the wedge, but without any other injury to the Chair.

Mr. McConochie exhibited to the meeting specimens of the Improved Chair, and the Chair that was tested in the experiment last described, with the rail in it, showing the fracture that took place.

Mr. McConnell inquired what angle had been adopted for the inclination of the wedge-piece in the Chair?

Mr. McConochie replied, that from their experience an angle of 45° was considered the best, to distribute the strain most uniformly, vertically and horizontally; they had tried a more acute angle at first,

and tested the strength of the chair by a heavy weight falling upon it until it was broken.

The CHAIRMAN inquired how the Chairs had been found to stand where they had been laid down in regular use?

Mr. McCONOCHIE replied, that three or four miles of one line were laid with these Chairs on the Liverpool, Crosby, and Southport Railway, part of which had been laid five months; a few hundred yards had also been laid with them, for about three months, at the entrance to the Liverpool Station of the Lancashire and Yorkshire Railway, where there was a large traffic constantly working over them with heavy engines; the road was found to keep in better order with the Improved Chairs than with the ordinary ones, and was smoother to run upon, and nothing had been done to the Chairs since they were first laid down.

The CHAIRMAN observed, that he remembered the circumstance alluded to in the paper of the Chairs tried on the London and Birmingham Railway, but he had no recollection of the head of the rail being injured, the Chairs had the effect of splitting the ends of the rails; his impression was, that the rail was entirely suspended, not resting on the bottom, and the object was to steady the rail in the Chair. The fracture took place in the centre of the web, spreading three or four inches lengthways into the end of the rail; he then came to the conclusion that the best support for any girder is at the bottom of the underside, where the strain is simply compression of the material.

Mr. McCONOCHIE said he had tried the effect of reducing the thickness of the web of the rail at the ends, by planing off a portion on each side of some that were laid down, in order to test this point experimentally, but no signs of splitting were yet perceived; though, of course, such a tendency might not show itself for a considerable time.

Mr. McCONNELL remarked, that the rail being gripped as in a vice, by resting between the two inclined surfaces, there would only be compression upon the metal, not any force tending to draw and tear it asunder vertically.

The CHAIRMAN doubted whether any such grip of the Chair could be considered practically to hold the rail under the hammering and clattering action of heavy engines running over it at speed.

Mr. FOTHERGILL observed, that with the sinking of the sleeper the key would throw a cross strain upon the end of the rail, tending to

split it, from the length of leverage given by the grip of the Chair upon the key and rail.

The CHAIRMAN remarked, that there would certainly be that strain, though it might be a question whether the actual amount of it was sufficient to cause an injurious effect. A long time was required before the effect on the rails was apparent in those alluded to on the London and Birmingham Railway; it was perhaps 1½ years before it became an extensive defect.

Mr. McCONNELL inquired whether the Chairs were cast chilled?

Mr. McCONOCHIE replied, they were sand castings; they were found sufficiently accurate without being chilled.

Mr. E. A. COWPER asked whether any difficulty was found in getting a fair bearing for the rail on each side, by casting the Chairs so that the two jaws should be an equal height?

Mr. McCONOCHIE answered, that it was found quite sufficient to leave the casting rather proud in the shoulder, so as to bear first in the neck of the rail, that the pressure might not come too much on the outer edges of the chair and wedge.

Mr. E. A. COWPER thought the deflection at the joint would cause a tendency to split the rail end, and that fishing-pieces would be better, as they would throw a less proportion of strain upon the rail; a combination of the two, namely, fishing-pieces at the joint, with these Chairs as intermediate chairs, would make a nearly perfect road.

The CHAIRMAN observed, that the same objection of the strain applied also to the fishing-pieces, though in a somewhat less degree. He inquired whether the weight of the new Chair was not rather more than that of common Chairs?

Mr. McCONOCHIE replied, that they were about the same weight; the new Chairs were about 28 lbs., and the common ones 25 lbs., on the Liverpool, Crosby, and Southport Railway. There was less deflection than with the ordinary Chairs, nor was there any injurious strain perceptible; no failure of the Chairs had occurred, on the contrary, the Engineer of the Line wanted to reduce the weight of the Chairs to the 25 lbs. in future, though he (Mr. McConochie) did not recommend any diminution in their weight.

The CHAIRMAN said he would rather advise that the Chairs should be made heavier, than any reduction in the weight; the main source of

durability in the permanent way was the absolute weight of material. and he thought it a great mistake to attempt a reduction of the weight.

Mr. McConochie observed, that he had been struck with the great importance of steadiness of road to ensure the efficient working of locomotives; the steadiest engine was made unsteady by an imperfect road.

Mr. R. Williams said he had seen and travelled over the part of the Liverpool and Southport Railway where these Chairs were laid down, and there was a remarkable difference in the steadiness of that part of the road in comparison with the opposite line, which was laid on common Chairs. It was an unfavourable situation, as the ballasting of the road was very light and loose, and the engines used were of the heaviest class, having, he believed, 13 tons on the driving wheels.

Mr. S. Lloyd, jun., remarked, that as some rails on the Liverpool, Crosby, and Southport Line had been laid down with these Chairs for five or six months, in which the web of the rail was only ½ inch thick, and as the opening pressure of the Chairs on these rails had not been found to do them any injury, he did not see that these Chairs could prove at all injurious where the common sections of rail were used, as in these the thickness of the web varied from ¾ to 1 inch.

Mr. McConochie stated that his object in reducing the thickness of the web in the rails had not been so much to show that the Improved Chair would answer with a lighter section of rail, as to construct a rail which, while no heavier than the ordinary rails, had a greater amount of available wearing surface. The metal taken out of the web, he transferred to the heads of the rail.

Mr. McConnell thought that Mr. McConochie was quite right in this, it being of the first importance to obtain the greatest amount of wear out of a given amount of material; a point requiring much attention in railways. The Improved Railway Chair appeared plainly a step in this direction.

The Chairman said they would be very glad to have a report at a future time on the further results of experience in working the Improved Chair; and proposed a vote of thanks to Mr. McConochie for his Paper, which was passed.

The following Paper, by Mr. J. D. Morries Stirling, was then read :—

ON IRON, AND SOME IMPROVEMENTS IN ITS MANUFACTURE.

The following remarks will but slightly touch on the ores, chemical composition, and general manufacture of Iron; these subjects being greatly too important to be treated of in a communication like the present, and requiring much more research and time than the writer can at present devote, even did he feel himself qualified to undertake the task.

It is most desirable that these subjects should be thoroughly studied, as we are certainly more ignorant of the nature and qualities of iron, and of the differences produced by slight modifications in the mode of manufacture, by varieties of fuel, ores, fluxes, &c., than we are of the nature of any other article of manufacture, and it is to be regretted that in a district like this, where iron manufacture is all-important, so little has as yet been done to elucidate the theory and to improve (on scientific and unerring grounds) the general make of iron, which the writer believes is only to be accomplished by our becoming thoroughly acquainted, as well with the chemical constituents of the various ores, fluxes, &c., as with the changes which these undergo in the various processes of calcining, smelting, refining and puddling. To do this is probably not in the power of those actively engaged in the making of iron, as their other pursuits would materially interfere with the carrying out the necessarily long series of experiments which would be requisite; and, even could such time be devoted to the pursuit, then we should only have, in all probability, the results of trials made in one district.

There is no doubt that many most valuable improvements have been introduced (more especially of late years) by ironmasters and others connected with the iron trade, but these have chiefly had reference to the later stages and finishing processes in iron making, and to the machinery connected with these processes. Of the chemistry of the blast-furnace, of the changes produced by the process of refining, and in puddling, we are still ignorant.

Having devoted a good deal of time to this subject, the writer may be allowed to say, that the more he has studied it, and the more he has seen of iron making, the more convinced he is of our ignorance, and it is to be hoped that some steps will be taken to improve our knowledge and render the various processes certain and economical.

The improvements in iron-manufacture which are touched on in the following remarks, are not of the nature of those alluded to above: they are of an inferior class, and should properly be called improvements in iron, or in the manufacture of certain kinds of iron for certain purposes.

It will be unnecessary to enter minutely into the various processes for converting the iron ore into cast and malleable iron, or to describe at length the various materials used.

The chief varieties of iron ore which are used in this country are the Clay-band, the Black-band, and the Hematite. From the Hematite the purest pig-iron and strongest bar-iron are said to be made: and from Clay-band a stronger malleable iron is generally supposed to be obtained than from the Black-band, but the various qualities can be altered by the judicious ironmaster, and malleable iron of as good quality can be produced from Black-band as from the Hematite or Clay-band. The writer does not here allude to improvement of quality by mixing different ores (by which it is well known the bad qualities of some descriptions are entirely removed), but to the skilful treatment of one or more ores of a somewhat similar character.

The first stage in the manufacture of iron is the conversion of the ore into cast-iron, which is accomplished in various ways. In Great Britain, the ore, after being calcined, if necessary, is introduced with layers of coal or coke, and a flux (usually a carbonate of lime), into a large furnace, and a strong blast (either hot or cold) is urged through the previously kindled mass, to accelerate the combustion of the fuel, and the conversion and fusion of the metal, which is usually tapped from the furnace once in the twelve hours, and run into pigs or ingots, which go by the name of "hot or cold-blast iron," according to the nature of the blast employed. The

subdivisions of both these sorts of iron are the same, viz., Nos. 1, 2, and 3, when for foundry purposes, and forge or white iron when intended for being converted into malleable iron; these numbers and qualities of iron are supposed to differ from each other in the quantity of carbon contained in each, although this is doubted by many eminent chemists. No. 1 is certainly darker, softer, and more carbonaceous-looking than the other numbers, and forge or white iron appears to contain very much less carbon than any iron intended for foundry purposes: but, as we see a similar effect produced on foundry iron by rapid chilling to that produced in forge iron by the supposed abstraction of carbon, it will perhaps be more readily admitted that colour is not a test (or at least not a certain one) of the quantity of carbon which iron contains.

It may be here remarked, that the Nos. 1, 2, 3, give *no real idea* of the nature of the iron; they are relatively comparative, and only indicate the *differences between cast-iron of the same district and make;* thus, what is called No. 1 in Wales, resembles hard No. 2 in Scotland, and corresponds to Staffordshire No. 2 (average); Welsh No. 2 is fully as hard as Staffordshire No. 3, or Scotch No. 4, (a brand), intermediate between No. 3 and forge iron. As a general rule, Nos. 1 and 2 are adapted for small castings, Nos. 2 and 3 *mixed*, for medium castings, and No. 3, or 3 and 4 in Scotland, or 3 in England, for heavy castings; but the mixtures of Welsh and Scotch, or of Staffordshire, Welsh, and Scotch, are found to make stronger and better castings than those made from one sort of iron.

This mode of producing strong castings has been long practised, and is in many places convenient; and the increase of strength is no doubt satisfactory, but there is still a want of uniformity in result, and an occasional difficulty in keeping to the proportions, and even in obtaining the brands specified by the engineer or architect, or chosen by the founder on his own experience.

It seemed to the writer very desirable therefore to obtain, if possible, a kind of iron which should be either uniform and constant in its strength, or, at least, *not under a certain standard*, and, after numerous experiments and trials, he attained this object by making certain mixtures of cast and wrought iron, which have been called "Toughened Cast-iron."

Allusion has already been made to the different numbers of cast-iron, and to their qualities; and it ought further to be stated that No. 1 is considered the weakest, and No. 3 the strongest. To render these uniform in strength, and at the same time to equalise *that of cast-iron from different districts*, it is only necessary to vary the quantity of wrought-iron introduced, by which means all other mixture is avoided, and so much greater strength insured, as to allow a margin for considerable variation in strength, from any accidental defect, as well as for a diminution in weight, taking the averages of the toughened cast-iron and of the best mixtures.

*Transverse strength of bars, 1 inch square, 4 feet 6 inches between supports.**

Cast-iron, average breaking weight...	436 lbs.
Toughened cast-iron, ditto	733 „

*Tensile strength.**

Cast-iron, average breaking weight	7·036 tons.
Toughened cast-iron, ditto	11·790 „

Crushing strength.

Cast-iron, average crushing weight	38·582 tons.
Toughened cast-iron, ditto	59·522 „

To render the above more intelligible, the proportions are given below, which have been found to bring very soft Scotch (No. 1 hot-blast), and very hard Welsh (No. 2 cold-blast), to nearly the same strength.

Scotch, No. 1 hot-blast, breaking when unmixed at	430 lbs.
With a mixture of 33 per cent. of wrought-iron scrap, broke at	713 lbs.
The same Scotch iron as the first, with only 20 per cent. of malleable scrap, broke at about	620 lbs.
Showing a deficiency in the quantity of the scrap.	
Welsh, No. 2 cold-blast, breaking when unmixed at	440 lbs.
With a mixture of 10 per cent. of wrought-iron scrap, broke at	689 lbs.

* The averages of the transverse and tensile strengths are from the experiments of Mr. Hodgkinson, in the Government Report and elsewhere, and other experimenters; Mr. Hodgkinson is the sole authority for the resistance of crushing force.

The results obtained by Mr. Hodgkinson are very favourable, as shown in the following table, where the breaking weights of common cast-iron and toughened cast-iron are given, from the Report of the Commissioners appointed to inquire into the strength of iron.

Table of Comparative Strength of Cast Iron.

Description of Iron Bars, all two inches square.	Transverse Breaking Load, in Centre.	Tensile Breaking Strength.	Crushing Strength.
	lbs.	Tons per inch.	Tons per inch.
Toughened Cast Iron, with 20 per cent. wrought scrap	2174	11·50	54·64
Low Moor, No. 1	1207	5·67	27·00
Blaenavon, No. 2	1220	7·46	49·11 30·50
Warrington best Gun Mixture ..	1375	—	—

Comparative trials on a larger scale, made by Mr. Owen (by command of the Admiralty), give equally satisfactory results, as the drawings, Figs. 1, 2, 3, 4, Plate 4, show (Compare 1 with 3, and 2 with 4). Tensile strength, according to Mr. Owen, 12·50 tons.

Since these experiments and trials were made, the toughened cast-iron has been successfully used in the construction of several public works, Windsor Bridges, Chelsea Bridge, Yarmouth Bridge, &c., &c.; and it may be mentioned that by being allowed to reduce the scantling in proportion to the increased strength gained by employing the toughened cast-iron, the contractors for the heavy castings of the Manchester Viaduct were enabled *profitably to fulfil* their contract, whereas had they used common iron, and been confined to the specification, they would have been heavy losers.

For shafting, rolls, pinions, cog-wheels, cast-iron railway-carriage wheels, cylinders, and other castings where strength and closeness of texture are desirable, the toughened cast-iron will be found most useful; also, cast-iron which will not chill in its unmixed state, readily chills with less loss of strength than usual, when mixed in proper proportions with malleable iron.

To ensure that the proper proportion of malleable iron is contained in each pig, and also to render the mixture more easily con-

veyed from place to place, the writer prefers making the mixture at the blast-furnace, and this is done by distributing the proper weight of malleable scrap in the moulds into which the melted iron is to be run. It is thus firmly fixed, and melts more easily and regularly with the cast-iron in the cupola or other furnace; the cast and wrought iron heating gradually to the melting point of the former, when the wrought-iron is easily acted upon, and fluxed by the cast-iron.

The process of converting cast into malleable iron is much more varied than that of converting the ore into cast-iron. In some districts a great portion of the cast-iron is refined previous to its conversion; in others little refined iron is used, and in some works cast-iron is at once converted into malleable iron; and this latter process seems to be gaining ground.

Refining is perhaps the least understood, and the least capable of being explained, of any process connected with iron-manufacture. The iron is kept in a fluid state in contact with carbonaceous matter exposed to a blast, and although it would seem that by such means more carbon *ought to be combined* with the iron, experience shows that a great change is produced in the nature of the metal, and that, as far as we know, the *quantity* of carbon is *diminished*, and the iron rendered more nearly akin to malleable iron, or at least so altered as to be more quickly converted into it.

Refining is an expensive process, great waste of material being unavoidable, but it is still necessary for certain descriptions of iron, and the expense is partly compensated by the greater quickness with which the conversion takes place in the puddling furnace.

Puddling is the last and most important process in the conversion of cast into malleable iron. It is still an extremely rude one, and its theory is not understood; it consists in melting in a peculiarly-constructed air furnace, refined or cast iron, or a mixture of them, and as soon as the fusion is complete, in continually stirring the melted metal till spicular or granular particles show themselves. Previous to this the melted metal swells up, and what is technically called boils; gas is evolved, and this appears to be the period at

which conversion commences: the solid particles increase in quantity, and the whole mass acquires a semi-solidity; the workman keeps collecting the more solid portions and forming them into balls, which become larger and larger, until the whole of the malleable iron is collected, and nothing remains but what is called cinder, in a perfectly fluid state, which is afterwards removed from the furnace by tapping, and again used in certain proportions along with ore in reproducing cast-iron. On the removal of this cinder from the iron, by puddling, squeezing, and rolling, the quality of the resulting wrought-iron very much depends.

To avoid the process of refining, to shorten the process of puddling, and to improve the quality of the resulting wrought-iron, are undoubtedly most desirable. The writer has endeavoured to accomplish this, and has reason to believe that partial success has attended his efforts. Instead of using refined iron, a mixture of wrought and cast-iron (as already described) is taken, and after being melted and run into pigs or slabs of the requisite size, it is puddled in the usual way, and the process of puddling is found to be thus so shortened, as to allow of from one to two heats more being brought out in the course of the twelve hours; the yield is greater, and the quality of the iron is much improved as regards fibrousness and tensile strength, rendering such iron particularly well adapted for cable iron, tension bars, shaftings, axles, &c., but not for the wearing surfaces of rails, nor for the tires of wheels.

Before proceeding to touch on certain other processes which the writer believes to improve iron for special purposes, it may be well to point to some alloys of cast-iron, as the making these led him to make the addition of the same and other metals to wrought-iron.

The first is an alloy of iron and tin, which is extremely hard, sonorous, and capable of receiving a very high polish; the addition of manganese, and a very small per-centage of zinc, gives somewhat greater tenacity. Bells made of these alloys have a pure and clear tone. Cast-iron will take up from 20 to 25 per cent. of tin.

Cast-iron alloyed with zinc becomes closer in its texture, and, as far as the writer's experiments have yet gone, stronger, and not less

malleable. Alloys of bismuth, antimony, copper, and silver, possess some scientific interest, but it would be out of place to touch on them now.

Having observed the hardening effect which tin produces upon cast-iron, the writer tried a similar mixture in the puddling furnace. and found a corresponding result, with this essential difference,— that whereas cast-iron will take up about a fifth of its weight. wrought-iron is rendered too hard for subsequent working by any quantity exceeding one per cent.; and taking the various descriptions of iron (Staffordshire, Scotch, and Welsh), one-half per cent. of tin produces a description of iron crystalline, close in texture. and harder than common wrought-iron.

This quality of iron appeared to be suitable for the wearing surfaces of rails, and tires of wheels, and subsequent trials which have been made have fully confirmed this opinion. Lamination is prevented, and the rail, when properly made, wears smoothly and evenly. As in all iron, and particularly in rails, much depends on manufacture; but points and crossings made of this hardened iron, and rails upon sharp inclines, where the wear previously had been very rapid, have been found to last more than double the time of any rails previously tried, and as they are yet not worn out, it is at present impossible to say how much longer they will last. The writer does not believe their increased duration to arise solely from the *greater hardness*, but more from the peculiar crystalline texture and fine grain of the iron resisting the lamination, which great speeds and heavy engines so rapidly produce. The sections of the rails in Figs. 15, 16, 17, Plate 3, show the proportion which it is considered best that the crystalline should bear to the fibrous iron, or to whatever other iron the rail may be composed of.

The addition of zinc, its oxides and other ores, produce the very opposite effect to tin, and the other metals above named. Iron of what is called cold-short quality, is rendered by this means, fibrous tough and strong; red-short iron is also improved in quality by the same means, but it is found that a larger addition of zinc or its ores or oxides is required to effect an improvement in red-short. than in cold-short iron. The quantity necessary to improve cold-

short iron varies much in different districts, and each peculiar iron requires to be separately considered; it is also necessary to know the per-centage of zinc in the ore, if ore be employed, and to ascertain that such ore does not contain foreign matters, which might counteract the effect of the zinc. The addition of these metals to the iron is best made when the iron in the puddling furnace is beginning to boil.

The writer was much gratified to observe in the American Department of the Great Exhibition, a confirmation of his experiments on this subject. Iron, naturally cold-short and red-short, being rendered free from each of these qualities by the addition of an ore of zinc; samples in all stages of progress were exhibited.

Table of Comparative Strength of Wrought Iron.

Description of Iron.	Tensile Breaking Strain.	Deflection with Strain of 9½ cwt.	Permanent Set, in lengths of 2½ feet.	Final Stretch in length of 2 feet.
	Tons per in.	Inches.	Inches.	Inches.
Hardened Wrought Iron, with ⅔-rds per cent. Tin.	22·92	1·42	1·02	¼
Toughened Wrought Iron ..	27·81	—	—	—
Dundyvan Best Bar	24·33	2·02	1·60	3½
S. C. Crown average result ..	24·47	—	—	—
Hartley's general average of Bar Iron	23·33	—	—	—

Had the limits of a mere sketch like this permitted, the writer would have entered on the consideration of the relative qualities of cold and hot blast iron, and of the effects produced by the use of cinder; also, on some combinations of iron with the earthy bases, and on the effects of various salts and fluxes in the blast and other furnaces. Several other alloys of iron possess considerable interest, and in conclusion, allusion may be made to a remarkable property which iron possesses of closing the grain of other metals and alloys to which it is added in minute quantity.

Mr. STIRLING exhibited a number of specimens of the toughened wrought-iron in bars, and the hardened wrought-iron, as applied to the surface of rails, showing their fractures, and specimens of the toughened cast-iron, showing the mode of mixing the wrought-iron scrap with the pig-metal; also specimens of an alloy of zinc copper and tin, and another of the same composition, with an addition of 1½ per cent. of iron, showing the great closeness and fineness of grain that were produced by this small admixture of iron. It was explained that it was advisable to alloy the iron with the zinc before mixing with the copper, otherwise there would be imperfection and unsoundness in the metal, the iron appearing in the form of what are technically called "tears."

The CHAIRMAN said he considered it a very important subject, and thought the paper showed valuable results of extensive practical trials combined with scientific inquiry. He asked at what period the tin or zinc was added to the wrought iron?

Mr. STIRLING replied, that it was put into the puddling furnace when the extreme of the boiling was just passed, or passing, and conversion just commencing, and the formation of spicula beginning. A more fluid iron required the metal to be put in at a later period, and iron that came to nature sooner required the metal put in earlier. It was difficult to give a definite rule, it could only be judged of by particular experience.

Mr. DUCLOS thought the presence of zinc in the iron was doubtful; from its volatility, the greater proportion would probably be dissipated in the furnace. He considered it more probable that the change in the iron was caused by the physical quality of the iron undergoing some alteration in consequence of the presence of the zinc.

Mr. STIRLING said he did not consider the mixture of zinc with the iron to be in all cases an alloy, as the proportion was occasionally only ¼-th per cent., and he felt uncertain about its mode of action; the quantity of zinc required varied very much, it had to be determined by experiment with the different ores and furnaces.

Mr. DUCLOS observed, that in some iron works he had been acquainted with in Belgium, he had never found any trace of zinc in the iron made from ore containing zinc, but metallic zinc was found to accumulate in the top of the furnace. Many years since a series of experiments had been made by M. Carsen, on various mixtures of iron with zinc and other metals, but they had not led to any practical appli-

cation. There was no question that sufficient attention had not been paid to the properties of the alloys that can be made with iron, and he was glad to see the steps taken by Mr. Stirling; he did not quite agree as to the want of knowledge of the iron manufacture, he thought there was a great deal of knowledge on the subject, but he would wish the principles carried out further.

Mr. STIRLING remarked, that in the case mentioned, in Belgium, two processes, smelting and refining, intervened, by which most if not all the zinc might be volatilized. There was no doubt that the practical making of iron was well understood, but not the theory and principles, otherwise the processes might be further simplified, and, as the result, iron would most probably be produced complete at one process, instead of two or more. He thought that further improvements would be more studied and accomplished when iron and coal were dearer.

Mr. McCONNELL said there was great room for improvement in railway tires and rails. If the tire now lasted 70.000 miles on the driving wheel of an engine, it was considered very good work. The expense of replacing tires, and of failure, was a very serious item; and if, by Mr. Stirling's process, the iron could be made to last longer, it would be a great source of economy and convenience.

Mr. BEASLEY inquired why the wrought-iron scrap was put into the pig mould, in making the toughened cast-iron?

Mr. STIRLING replied, that one object was to ensure a definite proportion for each charge: also, the wrought-iron melted more easily in the furnace, when mixed in that manner with the cast-iron, which seemed to act as a flux, the whole getting heated together; the cast-iron dropping, eats away the wrought-iron. If thrown separately into the cupola, part of the cast-iron would melt down first, and the two would not get uniformly mixed; the wrought-iron was liable to get oxidised, and wasted.

Mr. BEASLEY observed, that he was aware if the wrought-iron was thrown into the puddling furnace with the pig, it would burn away and not improve the quality; but if it was thrown into the fire a little time before the puddler commenced balling his iron, it would very much improve the quality.

Mr. STIRLING said that it was an old practice to add wrought-iron in the puddling furnace, in order to get a quicker yield; but it would

not melt thoroughly in that case, and make a uniform mixture. It should be first re-melted in the cupola from the mixed pig, to make a uniform mixture, and then re-melted, and worked in a puddling furnace.

Mr. BEASLEY remarked, that he had melted wrought-iron in the cupola, and then worked it in the puddling furnace, and he had found the result to be better than from the ordinary pig-iron alone, but it was not a sufficient advantage to make it worth the extra expense; he had obtained a greater yield.

Mr. STIRLING observed there was a process for melting wrought-iron, which was then converted back by decarbonising, to a state approaching to steel; it was intended to be used for small articles, such as snuffers' scissors, &c., instead of forging them.

Mr. ADAMS inquired about the application of the hardened iron to tires; the best scrap tires were found the worst to wear; they laminated more, and consequently he did not use them. Those he used were made he believed of two blooms, the lower one of scrap or other tough iron, and the upper one from a puddled ball not piled; the wearing surface was consequently crystalline iron, hard, not laminated, and was more suitable to resist the rolling and crushing action that the wearing surface of the tire was subjected to.

Mr. STIRLING replied, that he had seen a similar process extensively carried on; the lower part of the tire was made of No. 3 iron, and the wearing surface of No. 2 iron, consisting of two puddled balls hammered thoroughly, then re-heated and passed through rolls, and lastly welded to the No. 3 iron for the lower part. For such purposes as the wearing surfaces of wheel tires and rails, scrap iron was certainly the worst, from the inequality of the pieces united by weldings, necessarily numerous and irregular; when the wearing and rolling action came into effect, unequal wear and lamination of the surface must be the result.

Mr. T. FAIRBAIRN said the results of the trials he had made of the toughened cast-iron were a near approximation to Mr. Hodgkinson's experiments; but he did not think it would be prudent, or altogether safe for an architect or engineer to reduce the section of a girder to the extent which the relative transverse strength given in the tables would appear to warrant; he would rather retain the large section, and avail himself of the additional security which the use of the toughened iron undoubtedly gave.

Mr. STIRLING observed, that to obtain the full increase of strength would require different trials with different iron, in order to ascertain the best proportion of scrap; but in the right proportions from the general results of observations, he believed it might be confidently stated, that one-fifth of the weight might be taken from ordinary sections of girders, by using the toughened cast-iron, leaving a greater strength of girder; however, he would much prefer seeing all the strength of the ordinary section left for extra safety. The strengths given in the tables in the paper were chiefly taken from Mr. Hodgkinson, and were the average results of his experiments, showing an increase of transverse strength of 78 per cent.

Mr. R. WILLIAMS asked whether in practice any difficulty was found to arise in uniting the two qualities of hard and soft wrought-iron?

Mr. STIRLING replied, that no difficulty was found in the manufacture, and they were found to be soundly welded together.

Mr. R. WILLIAMS observed, that as the hard iron, which melted at a lower temperature than the soft iron, was necessarily the topmost in the pile when placed in the furnace to be welded, either that would be over-heated at the expense of its quality, or the inner piles would be under-heated, and endanger the soundness of the bloom. With regard to the lamination of tires, this was not so much owing to the fact of their being made of piled iron, as to the mode of piling; and by piling the bars edgeways instead of flatways, there was little, if any, liability to laminate. Puddled iron could be made hard or soft, at pleasure, according to the management of the process, without the introduction of any alloy into the puddling furnace.

MR. STIRLING replied, that the hard iron came quite as soon to a welding heat as the other iron, and a most perfect weld resulted.

Mr. MCCONNELL remarked, that in the manufacture of steel tires the steel did not lengthen so much as the iron in rolling, and it made a difficulty in rolling the tires to make them sound throughout; and he inquired whether any difficulty of that kind was found with the hardened iron, for the wearing surface of tires and wheels?

Mr. STIRLING replied, that in rails no separation between the materials had been found; he had not yet had experience in tires. On the Edinburgh and Glasgow Railway, on the steep incline, at Cowlairs, Mr. Adie had had rails hardened on this plan laid down for

some years, and had found them to last better than steel-covered rails, which had been also tried, and usually wore out in a considerably shorter time; the hardened rails were still going on well, and an additional portion of that line was now being laid with them. In consequence of the first rails manufactured being made too hard, they showed distinctly a tendency to separate, and the failure was valuable as experience; also they were made more liable to separate by the hardened piece laid on being round-topped in the pile; 50 or 60 rails made at the very first works where the plan had been tried, had been broken at different times for examination, and were found quite sound.

Mr. E. A. Cowper said he had used wrought-iron scrap mixed with cast-iron in the ladle, the metal being taken rather hotter than usual; it closed the grain of the iron very much, and was found advantageous in casting hydraulic presses, or other castings where a very close grain was required. He had put in as much as 15 per cent. of scrap.

Mr. Stirling observed, that he had never found that more than about 5 per cent. could be combined in that manner, and then the mixture must be more or less imperfect, and the metal would be partially chilled.

Mr. Cowper said he had not found any objection from the metal being cooled; it was taken pretty hot, and clean iron turnings were put into the ladle, and well stirred up, which secured complete mixture and fusion.

Mr. Slaughter inquired what was the relative cost of toughened cast-iron?

Mr. Stirling replied, that in a girder, if the section were reduced one-fifth, the cost would be cheaper; if the price of cast-iron were very low, the toughened iron would then be proportionately dearer.

Mr. Slaughter said he had tried the toughened iron for a number of locomotive cylinders, at the recommendation of Mr. Gooch, on the Great Western Railway, and found it made very fine, perfect, and sound castings, better than he had ever made before. He intended to continue the use of it, and considered it an excellent material for cylinder castings, and preferable for any purpose for which the strongest and best iron was required. He did not find the iron dearer, but on the contrary, less expensive than the iron he had previously used for the purpose.

Mr. STIRLING explained that the toughened iron might be made from a cheaper iron, such as the Scotch hot-blast, which at £3 per ton would be about £3 10s. for the cost of the toughened iron, which would then surpass in strength a dearer iron, such as Blaenavon at £5 or £5 10s. per ton; so that although the increased expense of the process was 10s. or 12s. per ton, the final cost was less, because a cheaper description of iron could be used, and a greater strength was at the same time obtained, as shown in the table of experiments.

Mr. SLAUGHTER said he had found that the toughened iron was less expensive. That which he used was made from Dundyvan or Calder iron, at £3 or £3 10s. per ton, and he found it better, when toughened, than the cold-blast iron which he had previously used at £5 or £5 10s. per ton.

The CHAIRMAN proposed a vote of thanks to Mr. Stirling, for his valuable and interesting paper, which was passed. He thought that important practical results were likely to follow from such an able investigation, and they were much indebted to Mr. Stirling for bringing it before them, and he trusted that he would continue the course, and favour the Institution with the further results.

The following paper, by Mr. Edward A. Cowper, of London, was then read:—

DESCRIPTION OF CUGNOT'S ORIGINAL INVENTION OF THE LOCOMOTIVE STEAM ENGINE FOR COMMON ROADS.

The object of the present Paper is to put the Members of this Institution in possession of certain information, which was obtained by the writer and your Secretary when in Paris, in reference to a Locomotive Steam Engine for Common Roads, which they saw in the "Conservatoire des Arts et Metiers."

Attention was first drawn to the subject by a model of a locomotive on three wheels, placed in a glass case in the "Conservatoire," and on making diligent inquiries it appeared that the actual engine itself was preserved in an old Church, that had been appropriated for the reception of various kinds of interesting machines, within the bounds of the "Conservatoire."

Permission to view the engine having been obtained, through the kindness of the Officer of the Institution, the engine was examined carefully, and general dimensions were taken, and a most interesting sight it was, to see the actual first machine that man had made to run alone by steam; it was a most creditable piece of work, considering when it was made, and would no doubt have caused a much greater sensation in the world than it did, had it not met with a serious accident after it had had two or three little walks only.

The Officer who showed the engine, explained that as it was passing along a street near where the Madeleine now stands, in turning a corner it overbalanced itself, and fell over with a crash: and, unfortunately, instead of being allowed to get the better of the bruise, and have another trial, it was at once locked up to keep it out of harm.

The following particulars have been translated from the French description, obligingly furnished to the writer by his friend, M. Armengaud, Professor at the "Conservatoire des Arts et Metiers."

The accompanying drawings, Figs. 1, 2, 3, and 4, Plates 5, 6, and 7, have been made by your Secretary from the drawing kindly sent by M. Armengaud.

It appears from documents collected by M. Morin, that a native of Lorraine, in France, named Cugnot, is entitled to the credit of having first constructed a carriage whose wheels were propelled by steam, and that in 1769 he made a locomotive on three wheels, to run on common roads, which was put in motion by a steam engine composed of two single-acting cylinders, whose pistons acted alternately on the single front wheel. Nicholas Joseph Cugnot, whose name has been hitherto overlooked in the history of the locomotive steam engine, was born at Void, in Lorraine, on 26th February, 1729, and died at Paris in 1804.

In the trials of Cugnot's machine, which were made at the Arsenal, in the presence of the Duke de Choiseul then Minister of War, General Gribeauval First Inspector-General of Artillery, and other eminent persons, the new vehicle, loaded with four persons, could not travel faster than 2¼ miles per hour; and the size of the boiler not being sufficient, it would not continue at work

longer than 12 or 15 minutes; it was then necessary to wait until the steam had again risen to a sufficient pressure before it could proceed further.

In 1770, Cugnot constructed a new machine, which gave more satisfactory results; the trials made by order of the Duke de Choiseul were however abandoned. The employment of steam engines in the place of animals to convey merchandise and passengers, could not become a practically successful application without the aid of the iron railways of England; and the difficulty of managing the machine on common roads stopped the invention of locomotive steam engines in France, and the efforts of Cugnot.

Whilst the first machine of Cugnot was in course of construction, in 1769, a Swiss Officer, named Planta, presented to the Duke de Choiseul a similar project; but perceiving that Cugnot's machine was preferable to his own, he did not proceed any further with it.

The following is a description of the machine:—Fig. 1, Plate 5, is a side elevation; Fig. 2, Plate 6, a plan; Fig. 3, Plate 7, a transverse section; and Fig. 4, a longitudinal section of the front portion.

The machine is composed of two parts; the front one (in place of the horse) being supported by a single driving wheel M; these two parts are united by a moveable pin E, and a toothed sector S, fixed on the framing LL of the front part.

The hind part T is merely a carriage on two wheels RR, intended to convey the load, and furnished in front with a seat B, for the conductor.

The fore part carries the copper boiler C, having a furnace inside, provided with two small chimneys; the two single-acting brass steam cylinders AA communicating with the boiler by the pipe O, and the machinery for communicating the motion of the pistons to the driving wheel M.

When one of the pistons P descends, the piston rod D draws with it the crank F, the catch of which causes the driving-wheel to make a quarter of a revolution by means of the ratchet wheel G, which is fixed on the axle of the driving-wheel; at the same time the chain H, fixed to the crank on the same side, descends also, and moves the lever I, the opposite end of which is raised, and restores

the second piston to its original position at the top of the cylinder, by the interposition of a second chain and crank.

The piston-rod of the descending piston, by means of a catch Y, causes the levers Q Q to turn round, moving the levers Z Z at the same time, and the chain fixed to them turns the four-way cock W, and opens the second cylinder to the steam, and the first cylinder to the atmosphere. The second piston then descends in its turn, causing the driving-wheel to make another quarter revolution, and restores the first piston to its original position; and thus the process is repeated.

In order to allow of changing the direction of the motion, and make the vehicle run backwards, the catch of the crank F was arranged in such a manner that it could at pleasure be made to act either above or below; in order to obtain a backward motion it was merely necessary to make it act on the upper side (changing the position of the spring which pressed upon it); then when the piston drove it down, it slipped over the ratchet wheel, and on the other hand the catch on the opposite side was raised by the lever, and turned the wheel a quarter revolution in the direction contrary to the original motion.

The conductor could further turn the carriage at an angle of from 15° to 20°, by means of a set of cog wheels N N, the last of which worked on the toothed sector S, and the first of which was turned by a spindle furnished at the top with a double handle in front of the seat B.

It will no doubt be in the recollection of most of the Members that the earliest recorded date of any other Locomotive was that of Murdock, in 1784, being 15 years later than Cugnot's engine; this engine was shown at work at a former meeting of this Institution.

Various persons have suggested the moving vehicles by steam, but none it appears so early as Cugnot, who actually ran an engine on land. Papin certainly, in his work published at Capel in 1699, suggested the use of ratchets, to convert the motion of a piston into a circular motion, but it does not appear that he had any idea of a locomotive.

After the date of Cugnot's engine, there are several persons whose names should be mentioned as having suggested the use of steam for locomotion, viz.:—Watt, in 1784; Oliver Evans, in 1786;

Professor Robinson, in 1795; and lastly, Trevithick and Vivian, in 1804, who not only ran a locomotive steam engine, but laid down *rails* for it to run on, at Merthyr Tydvil, in South Wales; and from this time the improvements introduced in locomotives and railways have been almost incessant, until we have now good smooth roads, and locomotives which run much faster than the wind.

The Chairman observed that the paper was an interesting record of the first attempt to apply steam to locomotion, and it appeared that they had not been hitherto giving the credit where it was really due. It was highly interesting and instructive to look back in tracing the progress of invention, to see how much the ingenuity of man had been directed to do something that was mistaken in its object. Generally the first attempts at invention commenced with a complicated machine, and the progress of subsequent improvements was gradually to simplify, a vast amount of ingenuity having been expended in overcoming difficulties which need not have been encountered.

A vote of thanks to Mr. Cowper for his communication was proposed by the Chairman, and passed.

The following paper, by Mr. Alexander Allan, of Crewe, was then read:—

DESCRIPTION OF AN OIL AXLE-BOX FOR ENGINES AND TENDERS.

An Axle-box for the driving-wheels of passenger engines, is shown in Figs. 1 and 2, Plate 8:—

A is the axle-box, of cast-iron, with two wrought-iron pieces cast in the sides of it.

B, the axle-step, which is carried 1 inch below the centre, to assist the sides in resisting the horizontal thrust; the inside edge W is also carried lower than the outside of the sponge-box, which carries the oil over the joint of axle-step and sponge-box joint.

S, the sponge-box; in it are placed one or two pieces of sponge, a ittle thicker than the distance from axle to bottom of sponge-box.

The axle is 6½ inches in diameter, and is supplied with oil by a covered syphon-box on the top of a straight tube about 3 feet long, and directly over the axle at X, which tube goes 1½ inches into the axle-box, and allows the engine to rise or fall 1½ inches, the delivery of oil on the proper place is therefore certain. I I are two pins ¾ inch round iron, to support the sponge-box.

E, the connection with the spring.

F, the pin which connects E with the sides of axle-box.

T, are pieces of wrought-iron cast in the axle-boxes; the lower ends are drilled for the pin F.

Axle-boxes for the leading and trailing wheels of passenger engines, also of tenders similar to those experimented on, are shown in Figs. 3, 4, and 5, Plate 8.

A, a cast-iron axle-box, with strong covered top to support the weight; under there is a cored-out hollow space, open at one end, and into this hollow the brass oil cup C is fitted.

B, the axle-step, 1 inch thick, with 3 snugs to resist the lateral strain, and with two counter-sunk oil holes.

C, the oil cup, with two tubes forming syphons; and H a handle for lifting it out to trim, &c.

S is the sponge-box, into which the narrow slip of sponge is placed, to catch the surplus oil as it leaves the axle bearing.

In accordance with the request at the last meeting of the Institution, the following experiments have been made on the consumption of oil in the axleboxes of tenders alone, fitted with oil receivers and sponges for collecting the oil, as described above: these experiments lasted seven days.

	s.	d.	
6·08 quarts of oil used, at 9d. per quart...	4	6½	
Four sponges at ½d. each	0	2	
For running 6,000 miles...	4	8½	or ¾d. per day.

N.B.—This result was obtained by running 1972 miles, with three tenders, and reduced to 6000 miles, as a mean of comparison with the axle-box described at the last meeting. The same system has been in operation on the Northern Division of the London and North Western Railway for the last ten or twelve years.

Mr. LEA inquired how many bearings had been tried in Mr. Allan's experiments?

Mr. ALLAN replied that the four bearings of the tender alone were tried; he had checked the experiment by trying it with other men, and found very little variation in the consumption: they had never exceeded one penny per day.

Mr. LEA said he should be glad to try a corresponding experiment with the new lubricating composition that he had mentioned at the last meeting of the Institution, which was quite applicable to that kind of axle-box, and he considered would effect a considerable further economy.

The CHAIRMAN remarked that in any comparative experiments, care should be taken to have the weights on the journals equal.

Mr. LEA said he proposed to try the journals on the opposite sides of the tender or carriage, with the two different lubricating materials at the same time, so as to ensure equality of load and mileage and all circumstances. He had obtained results from several railways of the cost of lubrication, and he hoped to have an opportunity to make further experiments before the next meeting of the Institution.

Mr. FOTHERGILL observed that the diameter and width also of the journals was of much importance in the lubrication; in small machinery, in particular, the size of journals made a great difference.

Mr. McCONNELL remarked that the most economical mode of lubrication was certainly an important subject for experiment on railways, as it was a serious item of expenditure; the two points should be tried separately—the best material for lubrication, and the best mode of applying it.

The CHAIRMAN proposed a vote of thanks to Mr. Allan for his communication, which was passed.

The Meeting then adjourned; and in the evening a number of the members and their friends dined together, in celebration of the Anniversary of the foundation of the Institution.

SUBJECTS FOR PAPERS.

Steam Engine Boilers, particulars of construction—form—heating surface—relative value of radiant surface in effect and economy—cost—consumption of fuel—evaporation of water—pressure of steam—steam gauges, high pressure and low pressure—explosion of boilers, and means of prevention—effects of heat on the metal of boilers, low pressure and high pressure—incrustation of boilers, and means of prevention—evaporative power and economy of different kinds of fuel, coal, wood, charcoal, peat, patent coal, and coke—moveable grates, and smoke-consuming apparatus, facts to show the best plan, and results of working.

Steam Engines, expansive force of steam, and best means of using it—power obtained by various plans—comparison of double and single cylinder engines—comparative advantages of direct-acting and beam engines—indicator figures from engines, with details of useful effects, consumption of fuel, &c.—contributions of indicator figures for the general book of reference kept in the Institution.

Pumping Engines, particulars of various constructions—size of cylinder and pumps, strokes per minute, and horse-power—number and size of pumps and strokes per minute—comparison of double-acting and single-acting pumping engines—particular details of different valves—application of pumps—fen-draining engines—comparative advantages of scoop wheels and centrifugal pumps, lifting trough, &c.

Blast Engines, best kind of engine—size of cylinder, strokes per minute, and horse-power—details of boilers—size of blowing cylinder and strokes per minute—pressure and means of regulating the blast—improvements in blast cylinders—rotary blowing machines.

Marine Engines, power of engines in proportion to tonnage—different constructions of engines—dynamical effect compared with indicator figures—comparative economy and durability of different boilers, tubular boilers, flat flue boilers, &c.—weight of machinery and boilers—kind of paddle wheels—speed obtained in British war steamers, in British merchant steamers, and in Foreign ditto, with particulars of the construction of engines with paddle wheels, &c.—screw propellers, particulars of different kinds, improvements in the form, number of arms, material, means for unshipping, horse-power applied, speed obtained, section of vessel—iron and wood ships, details of construction, lines, tonnage, cost, &c.

Rotary Engines, particulars of construction and practical application—details of the results of working.

Locomotive Engines, express, passenger, and luggage engines—particulars of construction, details of experiments, and results of working—speed of engines, cost, power, weight, steadiness—consumption of fuel—heating surface, length and diameter of tubes—experiments on size of tubes and blast-pipe—comparative expense of working and repairing—best make of pistons, valve gear, expansion gear, &c.

Caloric Engines, and Engines worked by Gas, Gun-cotton, or other explosive compounds—comparative consumption per horse-power per hour.

Electro-Magnetic Engines, particulars and results.

Water Wheels, particulars of construction and dimensions—form and depth of buckets—head of water, velocity, per-centage of power obtained—turbines, construction and practical application, power obtained, comparative effect and economy.

WIND MILLS, particulars of construction—number of sails, surface and form of sails—velocity, and power obtained—average number of days' work per annum.

CORN MILLS, particulars of improvements—power employed—application of steam power—results of working with an air blast and small stones—advantages of regularity of motion.

SUGAR MILLS, particulars of the construction and working—results of the application of the hydraulic press in place of rolls.

SAW MILLS, particulars of construction—mode of driving—power employed—particulars of work done—best speeds for vertical and circular saws—form of saw teeth—saw mills for cutting ship timbers—veneer saws.

OIL MILLS, facts relating to the construction and working, by stampers and by pressure.

COTTON MILLS, information respecting the construction and arrangement of the machinery—power employed, and application of power—cotton presses, mode of construction and working, power employed—improvements in spinning and carding machinery, &c.

MACHINERY for manufacturing Flax, both in the natural length of staple and when cut.

ROLLING MILLS, improvements in machinery for making iron and steel—mode of applying power—steam hammers—piling of iron—plates—fancy sections.

STAMPING AND COINING MACHINERY, particulars of improvements, &c.

PAPER-MAKING AND PAPER-CUTTING MACHINES, ditto ditto

PRINTING MACHINES, ditto ditto

CALICO-PRINTING MACHINERY, ditto ditto

WATER PUMPS, facts relating to the best construction, means of working, and application—best forms—velocity of piston—construction of valves.

AIR PUMPS, ditto ditto ditto

HYDRAULIC PRESSES, facts relating to the best construction, means of working, and application.

ROTARY AND CENTRIFUGAL PUMPS, ditto ditto ditto.

FIRE ENGINES, ditto ditto ditto.

SLUICES AND SLUICE COCKS, ditto ditto ditto.

CRANES, ditto ditto ditto.

STEAM CRANES, HYDRAULIC CRANES, PNEUMATIC CRANES, ditto.

LIFTS FOR RAISING TRUCKS, &c. ditto ditto ditto.

LATHES, PLANING, BORING, AND SLOTTING MACHINES, &c., particulars of improvements—description of new self-acting tools.

TOOTHED WHEELS, best construction and form of teeth—results of working—power transmitted.

DRIVING BELTS AND STRAPS, best make and material, leather, rope, wire, gutta percha, &c.—comparative durability, and results of working—power communicated by certain sizes.

DYNAMOMETERS, pressure gauges, indicators, governors, &c., construction and working.

STRENGTH OF MATERIALS—facts relating to experiments on ditto, and general details of the proof of girders, &c.—girders of cast and wrought iron, particulars of different constructions, and experiments on them—best forms and proportions of girders for different purposes—best mixtures of metal—mixture of wrought iron with cast.

DURABILITY OF TIMBER of various kinds—best plans for seasoning timber and cordage—results of Kyan's, Payne's, Bethell's, and Burnett's processes, &c. —comparative durability of timber in different situations.

CORROSION OF METALS by salt and fresh water, and by the atmosphere, &c—facts relating to corrosion, and best means of prevention—means of keeping ships' bottoms clean.

ALLOYS OF METALS—facts relating to different alloys.

FRICTION OF VARIOUS BODIES—facts relating to friction under ordinary circumstances—friction of iron, brass, copper, tin, wood, &c.—proportion of weight to rubbing surface—best forms of journals, and construction of axle-boxes, &c.—lubrication, best materials and means of application, and results of practical trials—best plans for oil tests.

IRON ROOFS, particulars of construction for different purposes—durability in various climates and situations—comparative cost, weight, and durability—roofs for slips of cast-iron, wrought-iron, timber, &c., best construction, form, and material—details of large roofs and cost.

FIRE-PROOF BUILDINGS, particulars of construction—most efficient plan—results of trials.

CHIMNEY STACKS of large size, particulars, mode of building, cheapest construction, &c.

BRICKS, manufacture and durability—hollow bricks, fire-bricks, and fire-clay—perforated bricks, cost of manufacture, and advantages.

GAS WORKS—best form, size, and material for retorts—construction of retort ovens—quantity and quality of gas from different coals—oil gas, water gas, &c.—improvements in purifiers, condensers, and gas holders—wet and dry gas meters—pressure of gas, gas exhauster—gas pipes, strength and durability, and construction of joints—proportionate diameter and length of gas mains, and velocity of the passage of gas—experiments on ditto, and on the friction of gas in mains, and loss of pressure.

WATER WORKS—facts relating to water works—application of power, and economy of working—proportionate diameter and length of pipes—experiments on the discharge of water from pipes, and friction through pipes—strength and durability of pipes, and construction of joints—relative advantages of stand-pipes and air-vessels.

WELL SINKING AND ARTESIAN WELLS, facts relating to.

COFFER DAMS AND PILING, facts relating to the construction.

PIERS, fixed and floating, and Pontoons, ditto ditto.

PILE-DRIVING APPARATUS, particulars of improvements—use of steam power—Pott's apparatus—the compressed air system.

DREDGING MACHINES, particulars of improvements—application of dredging machines—power required, and work done.

DIVING BELLS AND DIVING DRESSES, facts relating to the best construction.

CAST-IRON AND WROUGHT-IRON LIGHTHOUSES, ditto ditto

MINING OPERATIONS, facts relating to mining—means of ventilating mines, use of steam jet and ventilating machinery—mode of raising materials—mode of breaking, pulverising, and sifting various descriptions of ores.

BLASTING, facts relating to blasting under water, and blasting generally—use of gun cotton, &c.—effects produced by large and small charges of powder.

BLAST FURNACES—consumption of fuel in different kinds—burden, make, and quality of metal—pressure of blast—horse-power required—economy of working—improvements in manufacture of iron—comparative results of hot and cold blast.

PUDDLING FURNACES, best forms and construction—worked with coal, charcoal, &c.

HEATING FURNACES, best construction—consumption of fuel, &c.

SMITHS' FORGES, best construction—size and material—power of blast—hot blast, &c.

SMITHS' FANS, and FANS generally, best construction, form of blades, &c., with facts relating to the amount of power employed and the per-centage of effect produced.

COKE AND CHARCOAL, particulars of the best mode of making, and construction of ovens, &c.

RAILWAYS—construction of permanent way—section of rails, and mode of manufacture—experiments on rails, deflection, deterioration, and comparative durability—material and form of sleepers, size, and distances—improvements in chairs, keys, and joint fastenings—permanent way for hot climates.

SWITCHES and CROSSINGS, particulars of improvements, and results of working—advantages obtained by steeling points and tongues.

TURNTABLES, particulars of various constructions and improvements.

SIGNALS for Stations and Trains, and self-acting signals.

BREAKS for Carriages and Waggons, best construction.

BUFFERS for Carriages, &c., and Station Buffers—different construction and materials.

SPRINGS for Carriages, &c., buffing and bearing springs—particulars of different constructions and materials, steel, india-rubber, &c.—results of working.

RAILWAY WHEELS, wrought-iron, cast-iron, and wood—particulars of different constructions, and results of working—comparative expense and durability—wrought-iron and steel tires, comparative economy and results of working—solid wrought-iron wheels.

RAILWAY AXLES, best description, form, material, and mode of manufacture—comparison of solid and hollow axles.

The Council invite communications from the Members and their friends, on the preceeding subjects, and on any Engineering subjects that will be useful and interesting to the Institution;—also presentations of Engineering drawings, models, and books for the library of the Institution.

The communications should be written on foolscap paper, on one side only of each page, leaving a clear margin on the left side for binding, and they should be written in the third person. The drawings illustrating the communications should be on so large a scale, as to be clearly visible to the meeting at the time of reading the communication, or enlarged diagrams should be sent for the illustration of any particular portions.

INSTITUTION OF MECHANICAL ENGINEERS.

BALANCE SHEET,

For the year ending 31st December, 1852.

Dr.	£	s.	d.
To Balance from 31st December, 1851	202	15	2
„ Subscriptions from 18 old Members in arrear. . .	54	0	0
„ ditto from 145 old Members for 1852.	435	0	0
„ ditto from 21 new Members for 1852	105	0	0
„ ditto from 3 old Graduates for 1852	6	0	0
„ ditto from 1 Member in advance for 1853	3	0	0
„ Sale of Extra Reports.	7	9	1
„ ditto ditto Engravings	3	0	0
	£816	4	3

Cr.	£	s.	d.
By Printing and Engraving Reports of Proceedings. .	94	8	0
„ Stationery and Printing	25	7	11
„ Office Expenses and Petty Disbursements	24	7	1
„ Travelling Expenses	8	14	6
„ Parcels	5	2	7
„ Postages	27	15	5
„ Salary	350	0	0
„ Rent and Taxes.	107	7	6
„ Balance 31st December, 1852	173	1	3
	£816	4	3

(Signed) J. E. CLIFT, J. RAMSBOTTOM, } FINANCE COMMITTEE.

26th January, 1853.

PROCEEDINGS.

April 27, 1853.

The General Meeting of the Members was held at the house of the Institution, Newhall Street, Birmingham, on Wednesday, April 27th, 1853, Archibald Slate, Esq., Vice-President, in the Chair.

The Minutes of the last General Meeting were read and confirmed.

The Ballot-papers were opened, and the following new Members were declared to be duly elected:—

MEMBERS.

George Addenbrooke, Darlaston.
William Eales, London.
David Joy, Worcester.
William Mathews, Birmingham.
George M. Miller, Dublin.
Jonathan Rogers, Pontypool.
James Solly, Tipton.
Edward B. Wilson, Leeds.
Francis W. Wymer, Newcastle-on-Tyne.

HONORARY MEMBER.

William Sutton, Birmingham.

The following Paper, by Mr. William G. Craig, of Newport, was then read:—

ON IMPROVED INDIA-RUBBER SPRINGS FOR RAILWAY ENGINES, CARRIAGES, &c.

In order to explain the difficulties which have been contended with and surmounted by the use of these springs, the condition of the roads upon which they have produced such satisfactory results has to be noticed, and the causes which first led to the introduction of India-rubber as a substitute for steel, in bearing springs, buffers, and draw springs.

The Western Valleys Lines of the Monmouthshire Railway and Canal Company, (upon which the writer is Locomotive Superintendent,) consist of twenty-five miles of tramway, exclusive of branches, and worked by heavy coupled engines of the most improved construction. The tramplate is laid by means of chairs upon transverse sleepers, about 3 feet apart, and an intermediate sleeper at the joints. This plate, although heavy, (about 73 lbs. per yard) is of very weak section, as shown by the accompanying drawing, Fig, 4, Plate 9, and there is consequently considerable deflection in it, a tendency to rise at the joints, and for the sleepers to work loose; the effect of this is, to cause a much greater expenditure of power necessary to overcome a series of rising and falling gradients, than would be the case upon an edge rail, and an undulatory motion of the engine is caused, which is extremely destructive to the steel springs hitherto in use on this line. The curves are also unusually sharp, (some being under five chains radius, and the majority under twenty chains,) which is productive of a prejudicial effect on the wheels, buffers, and other parts of the engines, carriages, and waggons. The gradients are very heavy, (some being 1 in 54,) producing a much greater strain on the draw-bars and couplings than is to be met with upon ordinary railways.

Upon such a road, the inconveniences attending the use of steel springs were both numerous and formidable. In addition to the continual repairs which were required by the springs themselves, the injury done to the permanent way, arising from the unequal action of the springs, and the violent concussions they were subject to, when they were totally disabled (as was frequently the case), was large in amount and of continual occurrence, and of a character that involved considerable expense in repairs. Some idea of the damage thus occasioned may be formed from the fact of the wheel tyres requiring to be replaced at least every eight months, having become worn by that time into a series of flats, more nearly resembling an irregular polygon in outline than the circumference of a circle.

Fig. 4 shows a section of the engine tyres used on the tramways: they are steeled on the wearing surface. With regard to the springs themselves, it may be proper to mention here that the item of expenditure for steel springs (including wages for repairing them) was £251 9s. 9d. in six months, for fifteen engines only.

Such then were the circumstances when it was deemed necessary to test the application of India-rubber to the various purposes before mentioned, and the results have been attended with such marked success, as to exceed the most sanguine anticipations entertained.

The India-rubber Springs described in this paper are constructed on Mr. Coleman's plan. Fig. 1, Plate 9, represents the first form of application, for engine-bearing springs. It consists of a cylinder of prepared India-rubber A, 9 inches long and 9 inches in diameter, with a hole through it of 1¾ inch for the spring pin; it is supported by a wrought-iron plate 1⅛ inch thick, which rests on a shoulder on the spring-pin, and is covered by a wrought-iron plate and crossbar, through which pass the spring links attached to the outside framing at the bottom, and secured by set and jam nuts at the upper end. The India-rubber is prevented from undue lateral expansion by two ¾-inch round iron hoops, and from internal compression and friction on the spring pin, by a helical coil of strong wire; instead of this wire, wrought-iron ferrules are now used. To obviate an inconvenience which has been occasionally complained of, in passing over unusually rough portions of the road, viz., the jumping motion of the engines, from the great elasticity of the springs—it was found necessary to insert between the bottom plate and the top of the framing another smaller cylinder of India-rubber B, for the purpose of absorbing the recoil of the spring, and to prevent any motion being re-communicated from the spring to the framing. This had the desired effect, and the engine was found afterwards to run uniformly steady, at all varieties of speed, and however great the inequalities of the road.

Upon engines with inside framing, or where sufficient space for the springs could not be obtained, two cylinders or sometimes three were used, AAA, as in Fig. 2, which represents the springs in use on the engines Nos. 2, 3, 4, and 5.

In the application of the same description of spring to a tender, the India-rubber is 6⅛ inches diameter, 7 inches long, with a 1¾ inch hole, and bears against a cast-iron bracket bolted to the framework of the tender, the bottom plate being supported by a set nut on the spring pin, which passes loosely through a hole in the underside of the bracket, and rests on a wrought-iron plate, ⅜ inch thick, made to fit in the top of the axle-box.

Fig. 3 shows a similar arrangement applied to waggons. In the passenger carriages, two of these springs are used in pairs, in order to obtain a greater amount of elasticity, without increasing the distance between the centre of the axle and the sole bar, and a modified form of axle-box is introduced, to meet the requirements of the double cylinder of India-rubber. No horn plates are used in this case, their place being supplied by two guide rods, which pass through the axle-box and India-rubber cylinders, being firmly bolted to the sole bar by jaws on the upper ends, and kept in their places by diagonal stays at the lower ends. The axle-box is cast with a projecting hollow wing on each side, which is enlarged on the top, to afford a bearing for the bottom of the India-rubber cylinder, and leaving a capacious grease-box between them. The upper ends of the India-rubber cylinders are received into a cast-iron plate, fixed to the sole bar, and the arrangement of internal coil, or ferrules, and external hoops, is the same as previously described, with this exception, that one binding hoop only is used on each cylinder instead of two, in the case of waggons, rather greater elasticity being required for carriages. Some new passenger carriages with this description of spring are now in use on the Monmouthshire Railway.

Fig. 7, Plate 10, shows the present improved form of Engine-Bearing Springs. termed the Hydro-Pneumatic Spring. The object of this form is to obtain the same amount of elasticity with a less quantity of India-rubber, and is accomplished by thinning the cylinder of India-rubber AA internally, and in the increased space thus obtained placing a quantity of fluid B—water is used for this purpose—which, acting by hydrostatic pressure, distributes the pressure equally over every part of the internal surface, thus obtaining a much larger bearing surface than if the pressure were confined to the ends, and in fact producing precisely the same effect as a solid homogeneous cylinder of India-rubber. The fluid does not entirely fill the cavity in the India-rubber, at least not when first put in, but is adjusted to do so only on the spring receiving the maximum of impact; the air at the same time. which had before occupied the space left vacant by the fluid, retires into a chamber C for that purpose in the upper part of the casting, and being then in a state of considerable condensation, exerts a powerful elastic force, assisting the spring to regain its equilibrium. The air and fluid are prevented from escaping under the ends of the India-rubber cylinder by that part

of the casting which receives them being cast with a groove, so that on the application of pressure, the India-rubber forces itself into the minutest crevice, and a perfectly tight joint is obtained without the necessity of interposing any other substance.

A spring on this principle is applied to waggons in the same manner as the spring in Fig. 3, of very simple construction, and one that requires no alteration of horn plates or axle-boxes, but which, with a very little labour, may be applied to any existing waggon adapted for steel springs.

Fig. 8 shows the same spring, as applied to some new engines, now being made for this railway. In this case the spring is entirely beneath the footplate, in a hollow part of the framing, immediately above the axle guides, by which great compactness is obtained with increased strength of the frame. The internal arrangement is the same as shown in Fig. 7, but the spring piston DD is here cast in one piece with the axle-box, thus avoiding the necessity of using a spring pin, and at the same time dispensing entirely with suspending links, nuts, and bolts, thereby still further reducing the total weight of the spring, which in this case is brought to a minimum.

Fig. 6, Plate 9, represents the Pneumatic Buffer, in which the elasticity of a cylinder of India-rubber AA is combined with that of a column of enclosed air B. No fluid is used in this case, the position of the buffer and its mode of action not being favourable to its use; neither is it required, as buffers should be sensitive, more so than would be the case were fluid used. The transverse pins CC, riveted to the external or wrought-iron cylinder, serve to confine the fixed and moving part of the buffer, and pass through slots in the plunger to allow them sufficient play. In a cheaper form of this buffer, the external wrought-iron case D is replaced by a cast-iron one, for use where not liable to severe cross strains, Fig. 6 being only for extra strong buffers.

Fig. 5 shows a Draw Spring for the buffer plank of an engine, and Fig. 9, Plate 10, is a cheaper form (though equally efficient) for common waggons; and these are alike in principle, and only differ in their form and getting up.

The advantages resulting from the use of these springs may be thus enumerated:—1st, Reduction of Dead Weight. This item is more

extensive than appears at first sight, since the reduction of weight is not confined to the springs themselves, but extends, in a greater or less degree, to a variety of other parts of the engine, carriage, or waggon, on account of the smoothness of their action. This is particularly advantageous in the case of cast-iron, whose liability to fracture consists, not so much in the weight it has to carry, as its inability to resist strains, jerks, and concussions; these are, however, nearly altogether deadened by the use of these springs, so that a motion uniformly smooth and steady takes the place of one that is very injurious to railway plant, especially to engines; and as the working portions of an engine are made extra strong, with a view to resist the concussions they are subject to with steel springs, it follows that when these are no longer allowed to operate, they may be made lighter without in the least impairing their efficiency. The reduction in the springs themselves is, however, considerable; and the weight thus gained is valuable, particularly in the case of waggons, where it becomes available for tonnage. The amount of this reduction of weight varies, as shown by the following table, but may be taken on an average at from 3½ to 5 cwt. per engine, and the same for waggons.

Comparative Weight of India-rubber and Steel Springs.

Weight of Springs.	India Rubber.	Steel.	Reduction in Weight.
Engine-Bearing Springs.	Cwt.	Cwt.	Cwt.
India-rubber, 1¼ cwt... .. .. }	4¼		
Iron Work, 3 cwt. .. .. }			
Steel Springs taken off		8½	4¼
Engine Hydro-Pneumatic Springs.			
India-rubber, 1 cwt. .. .. }	7		
Iron Work, 6 cwt. .. .. }			
Steel Springs taken off		8½	1½
Tender-Bearing and Draw Springs.			
India-rubber, ¾ cwt. .. .. }	2¾		
Iron Work, 2 cwt. .. .. }			
Steel Springs taken off		11	8¼
Carriage-Bearing, Drawing, & Buffing Springs	4½		
Steel Springs taken off		9¾	5¼
Waggon-Bearing, Drawing, & Buffing Springs.	3½		
Steel Springs taken off		8¾	5¼

2ndly, Steadiness of Motion. This has been referred to before, and it may be added that the great steadiness of the engines with the India-rubber Springs is the surprise of every one who has witnessed their performance upon the imperfect road on which they are worked.

3rdly, Durability. Although sufficient time may not have elapsed to test the absolute durability of these springs, yet during the time they have been in use, in consequence of the heaviness of the work, if deterioration had commenced ever so slightly, it would have been observable; but in a large number of the India-rubber Cylinders that were examined, after being at work for various periods, varying from four to six months, in both engines, carriages, and waggons, in no instance was the slightest alteration visible from the day in which they were first used, nor the slightest permanent contraction in length or expansion in diameter perceptible: it may, therefore, be inferred that their durability far exceeds anything hitherto applied to the same purpose, and is fully equal to any reasonable expectation or requirement. The specimens before the meeting have been in use for the last five and six months, and corroborate this statement. The weight on each pair of the engine springs is from 4½ to 9¼ tons.

4thly, Saving in Repairs. The simple construction of these springs renders it almost impossible for any injury to happen to them, consequently little or no repairs are needed. As stated before, the cost of repairing the steel springs of fifteen engines for six months was £251 9s. 9d. The cost of repairing the India-rubber Springs of fourteen engines during the last six months was only £1 18s. The saving in the cost of repairs is not confined to the springs alone, but the engine itself, the carriages and waggons to which they are applied, and even the permanent way, share the advantage. It is found that fewer chairs are broken, fewer rails (plates rather) are bent, less grease and oil is used for the bearings, and the cost of maintaining the waggons is reduced when India-rubber is used. It is inferred with a considerable degree of probability, that from the absence of any jerk upon the axles, the tendency of the iron to become crystallized or altered in its nature and suddenly fracturing, so often complained of, and which has produced so many serious accidents upon railways, will by the use of these springs be nearly overcome, and the axles remain perfect for a much longer period, more especially as under the India-rubber Springs they show no tendency to heat.

5thly, Cost. The question of first cost does not properly belong to this paper, but it will be sufficient to state that a well-constructed India-rubber spring ought not, in any case, to exceed the cost of a steel spring of equal strength; but on the hydro-pneumatic principle it will be found to be considerably cheaper, especially for engines, amounting on an average to twenty per cent. saving on the old plan.

The foregoing remarks have been made chiefly with reference to Bearing Springs, but they apply equally to both Buffer and Draw Springs; and in proportion to the extent in which India-rubber is used in place of steel, does the improvement in the rolling stock become apparent, and the benefits resulting from its use more strongly developed. The Pneumatic Buffers, it is considered, have been subjected to a peculiarly severe test, few lines of railway in the kingdom possessing such disadvantageous circumstances. Almost every other description of buffer had been tried previously with the same want of success, until, from repeated failures, the attempt to obtain a permanent buffer was almost abandoned in despair, and solid blocks of wood were substituted for them in many instances. With these buffers, however, no failure has taken place, nor in any instance has their elasticity diminished in the slightest degree. In the accompanying table, the deflection of this description of buffer and the several kinds of springs, under different weights, is shown.

Table of Deflection of Springs.

Load.	Engine Single Spring.	Engine Triple Spring.	Engine Hydro-Pneumatic.	Waggon Spring.	Buffer Spring.	Draw Spring.
	Fig. 1.	Fig. 2.	Fig. 7.	Fig. 3.	Fig. 6.	Fig. 9.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
$\frac{1}{2}$ ton.	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{7}{8}$	$\frac{3}{16}$	1
1st ton.	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{7}{8}$	$1\frac{1}{4}$	$\frac{3}{4}$	$1\frac{1}{8}$
2nd ,,	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{5}{8}$	$\frac{3}{8}$	1
3rd ,,	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{3}{16}$	$\frac{3}{8}$
4th ,,	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{16}$	—	$\frac{1}{8}$	—
5th ,,	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{16}$	—	$\frac{3}{16}$	—
6th ,,	$\frac{3}{8}$	—	—	—	$\frac{3}{16}$	—

Before the application of India-rubber draw springs to the engines and tenders, the couplings were frequently breaking, and also the frame

ends; but since their adoption nothing of the kind takes place. Such are the advantages of these springs that their adoption promises to become general, and it will be shortly, without doubt, as rare to meet with a waggon unprovided with a draw spring, as it was formerly to meet with one.

In working 15,000 miles, the cost of repairs is found to be reduced in the engines using India-rubber springs, in corresponding engines of the two classes, from 5¾d. to 3¾d. per mile, and from 7d. to 3¼d. per mile.

It has been the writer's object in this paper to state rather what has been done than to speculate on what will be; but it is notorious that the ordinary steel springs are deficient in point of general efficiency, whether as regards elasticity, durability, or cheapness. It may be that competition may cause their manufacture to be less strictly attended to than formerly; or it may be, and most likely is, that the requirements of the present day have outstripped their ability to perform. However, be that as it may, it is well known that a substitute which shall combine the above requisites has been long desired; and the writer's hope, therefore, that this desideratum will now be supplied by the springs which have been described must be his apology for bringing the subject before the Institution.

Mr. Craig exhibited a set of the different descriptions of India-rubber Springs described in the Paper, and also specimens of the India-rubber Cylinders, taken out of various springs which had been at work on the Monmouthshire Railway, to show the effects of wear upon them. One cylinder had worked 8,850 miles in the bearing spring of an engine; another 14,060 miles in a carriage bearing spring; and an engine buffer spring that had been six months in constant use; all of them appearing uninjured by the work, not having suffered any permanent compression.

Mr. H. Wright observed that he had seen these India-rubber Springs at work on the Monmouthshire Railway, and they certainly worked very satisfactorily, and were much better adapted to that situation than steel springs. The case of that railway was

very peculiar; it was perhaps the worst in the kingdom for destructive action on the springs, from the great inequality and roughness of the road, which was not upon the edge-rail, but the old tramway system, and with very sharp curves; it was, indeed, impossible for steel to stand in the engine springs, and the steel springs were disabled very rapidly; but the India-rubber Springs appeared to stand the work well.

Mr. W. A. Adams said he was acquainted with these India-rubber Springs, and had witnessed their working on the Monmouthshire line; it was previously impossible to keep steel springs in order, from the violent jerks they were subjected to, and the substitution of India-rubber for steel in that case was an important improvement. As to the general application of India-rubber Springs, there was a special circumstance in favour of their use in locomotive engines, from the confined position and the want of space to fix a properly proportioned laminated steel spring, which might probably be otherwise made to work satisfactorily; but the steel springs generally used in locomotives were so short and stiff, that their elastic action was exceedingly imperfect, and they were consequently ill suited to withstand the violent concussions of a rough road. In the bearing springs of carriages the case was very different, and a long thin laminated spring was employed, which had a very easy, elastic action, so that in that case the advantage would be less felt of the substitution of India-rubber for steel. In applying the India-rubber Springs to carriages, it had to be observed that the bearing of the frame would be on four points only, instead of eight, requiring a stronger frame or cross-bars to distribute the strain.

Mr. Allan said he had made some trial of these India-rubber Bearing Springs on engines, and they worked very well—but he found them too elastic and liable to produce a jumping action; but the springs he had tried were of the kind first described, without provision for checking the rebound of the spring.

The Chairman inquired whether, if such re-action could be removed, the India-rubber Spring would be considered superior to steel?

Mr. ALLAN thought that very little friction or resistance would be sufficient to check the re-action, and the India-rubber would then certainly make a very good spring.

Mr. CRAIG observed, that the rebound complained of was quite stopped by the little resistance offered by the small second spring that had been subsequently introduced, but it was now found that the objection was quite removed by the water application in the new Compound Spring.

Mr. CLIFT inquired whether any difference was found between winter and summer in the action of the India-rubber? whether there was any more oscillation observed in hot than in cold weather? and whether the India-rubber was liable to any injury by the heat to which it was liable to be exposed from the boiler or fire-box of the engine?

Mr. CRAIG replied, that the India-rubber was not affected by the temperature, and no effect was found during the last severe winter; also in two tank engines one pair of the India-rubber Springs was exposed to great heat, probably as much as 240°, being very near the fire-box, but there was no perceptible effect. The material used for the springs was Molton's Prepared India-rubber; the raw gum would not stand exposure to heat, and the constant compression and elastic action.

The CHAIRMAN inquired what pressure there was upon the India-rubber when the springs were at work?

Mr. CRAIG replied, that the vertical pressure on the end of the India-rubber Cylinder, in the engine bearing springs, amounted to about $1\frac{1}{4}$ cwt. per square inch; a weight of $4\frac{1}{2}$ tons being supported on a cylinder 9 inches diameter, having a $1\frac{3}{4}$-inch hole in the centre. In the Hydro-Pneumatic Spring the pressure on the India-rubber was about 2 cwt. per square inch; he intended trying the exact pressure of the water with a Bourdon's Pressure Gauge, but had not been able to complete the experiments in time for the present meeting.

Mr. E. A. COWPER observed, that he understood a considerable trial of India-rubber springs had been made on engines upon the London and North-Western Railway, and inquired what kind of spring had been applied there, and what were the results? He had

also heard that on the Great Western they used India-rubber Springs, and now never hung an engine any other way.

Mr. Craig replied that the springs tried on the London and North-Western were with two or three cylinders of India-rubber, similar to the first arrangement described, and they were working very satisfactorily, and he believed were preferred to steel springs.

The Chairman inquired the relative cost of India-rubber and Steel Springs?

Mr. Craig said that the cost of the India-rubber Springs did not in any case exceed that of steel. Waggon springs were about £3 18s. per set, but engine springs were considerably less expensive than steel, there being so much greater proportionate weight of steel in the ordinary springs. By the introduction of water in the Improved Springs, the quantity of India rubber to support the same weight was reduced from 20 lbs. to 12 lbs. in each spring, which, at the cost of two shillings per pound, effected a considerable saving in the expense.

Mr. H. Wright observed that he was now making a number of waggons with the India-rubber Bearing Springs, in which a compact and economical arrangement of the spring was adopted, applicable to the ordinary construction of waggon frames. A specimen of the spring and axle-box was exhibited to the meeting.

The Chairman asked whether it had been found that an actual saving in oil or grease was effected by the use of the India-rubber Springs?

Mr. Craig said that considerable saving in this respect had been observed, but he was not able to give the exact results, and he would make a comparative trial for the purpose of ascertaining it; he considered that the removal of the harsh jerks that occurred with the rigid steel springs prevented waste, and caused the lubrication to be more perfect.

The Chairman observed, that he hoped Mr. Craig would continue his experiments on the application of India-rubber to Springs, and report the result at a future meeting; he proposed a vote of thanks to Mr. Craig for his Paper, which was passed.

The following, by Mr. W. Bridges Adams, of London, was then read :—

ON RAILWAY AXLE LUBRICATION.

In the economy of railway transit an idea has prevailed that increase of speed increases cost in a compound proportion, in many other things than the mere excess of fuel consumed in the locomotive. This is correct only in reference to imperfect appliances. If, for example, the rails deflect beneath the rolling loads, the substructure will be displaced, and increased speed will greatly increase the displacement. If the wheel peripheries be out of order, the greater the speed the greater will be the destruction ; and so also if the rail surfaces or joints be out of order. And in proportion as the springs are inefficient, *i.e.*, are non-elastic, or do not act through sufficient space to moderate the shocks, so will the destructive wear be increased by increased speed. But were all parts of the system—ballast, sleepers, rails, wheels, axles, journals, bearings, lubrication, and springs—rendered as perfect as is within the scope of mechanical art, there seems to be no reason why increased speed should involve any extra cost beyond the increased consumption of fuel, oil, and grease, provided all parts of the system be proportioned to each other.

In increasing speed with imperfect mechanical arrangements, one of the most prominent difficulties occurs in preventing axles and axleboxes from heating ; the cause of the heating is in the imperfect lubrication. The word lubrication literally signifies slipperiness, but this does not express the precise action. Oil, or grease, or soap, interposed between two metallic bodies moving one upon the other, is composed of a series of small globules, which keep the bodies separated, and serve as rollers. The surfaces of metallic bodies, however apparently smooth, are composed of salient and re-entrant angles of larger or smaller size, according as the metal is hard and polished, or soft and rough. Therefore the more imperfect the structure of an axle and bearing, the more viscid must be the lubricating material to keep them from contact. If the cushion of lubricating material be insufficient in extent, contact ensues between the salient angles of the metal, and heating takes place to such an extent as to boil away the lubricating material and drive it off.

In calculating the surface bearing of axles, there are two circumstances to consider. First, the actual weight to be borne; and, secondly, the amount of concussion adding to the effect of the weight, which latter will much depend on the efficiency of the springs to moderate the effect of the shock.

Before the advent of railways, mail coaches and private carriages, with a maximum weight of 3 tons, were constructed with axles case-hardened, and with a bearing surface on each arm equivalent to 30 square inches. This is equivalent to about 56 lbs. per square inch on the bearing.

Mr. Nicholas Wood, in his experiments on axle friction, found that with the best oil and with favourable circumstances, a superincumbent weight of 90 lbs. per square inch gave the minimum of friction.

Some of the earliest railway axle-bearings were 4 inches in length by 2¼ in diameter, something under 14 inches of total bearing surface, fitted according to Mr. Wood's calculations, only for a waggon of 2 tons total weight. It would seem as though these sizes had been calculated from the fixed shafting of factories, without any calculation of concussion. Probably this was the reason why viscid soap was substituted for fluid oil, increasing the toughness of the material used for lubrication to make up for the want of bearing surface. In railway practice it is found that the soap or grease which serves well in the winter, is too fluid in the summer, a sure proof that the bearing surface is far too small for any lubrication with oil, which offers the minimum amount of friction. A strong objection to soap lubrication is, that it requires a considerable amount of friction in the winter time to make it fluid; and it is sometimes difficult to start a train into motion when the grease has been frozen.

In the wheels of highway carriages, the oil chambers are contained within the wheels, and revolve with them, which process involves the efficient lubrication of the axle. In the axle-boxes of railway carriages the grease or oil does not revolve. In the highway wheels, the oil always has a tendency to rest in the well or magazine below the level of the axle. In the ordinary axle-boxes of railway carriages the grease or oil is above the level of the axle, and as the axle revolves, the oil or grease, or rather the grease (oil not being used, except in engines)

passes through a hole or holes in the bearing brass, which lies on the upper half of the axle; and thus the process is like that of a hand-mill, the lubricating material is supplied on the upper surface of the axle, and passes away at the lower like grist. To make the lubrication more certain, the holes are of large size, and this involves an evil by diminishing the bearing surface at the most important point. If these holes get stopped, the lubrication ceases and heating ensues; and there are no means to remedy the evil, save by lifting the bearing from the axle and inserting more grease.

Thus, in the ordinary railway grease-box, there is not only a great waste of grease, but also a very imperfect mode of securing lubrication. The well-made, case-hardened axles of a common road carriage are capable of running 5000 miles over a bad road with once oiling, with a small quantity of oil, while railway axles require greasing every 100 miles or less, with some few exceptions.

Impressed with these imperfections, the writer some years back began to consider the best means of remedying them. It was evident that the only mode of applying grease or oil to a large surface of the axle-bearing was at the under side. In the common mode of an open bottom, this was scarcely practicable, and the question was, could the bottom be effectually closed without so confining the axle as to make partial heating dangerous. This was accomplished by applying a flexible connection between the axle and the inner side of the axle-box, and making the bottom of the box tight. In this mode, the grease filling the lower part of the box, the whole under surface of the axle was bathed in it, while all dirt and grit were excluded. Moreover, the grease being as it were in a well below the axle, any accidental extraneous matters could sink to the bottom, and not be brought in contact with the wearing surface. And supposing the upper holes to be entirely stopped, lubrication would go on notwithstanding. It must be evident that feeding from above in all cases involves the chance of dirt getting to the axle, which feeding from below obviates.

To provide against accidental injury to the axle-bearings, the writer provided also for a mode of shrinking on a false bearing upon the axle arm, so that in case of cutting it might be removed and replaced. The following is a description of the axle-box invented and patented by the writer, in May, 1847, which is shown in the accompanying drawings.

Fig. 1, Plate 11, is a longitudinal section, and Fig. 2 a transverse section, of the axle-boxes employed on the North Kent line. The top of the box is circular for a peculiar arrangement of springs; the box is cast open-fronted with a moveable front A to attach by screws, a grease-tight joint being maintained by an elastic substance between. In this mode the interior of the box can be inspected, and a new brass applied, without lifting the carriage. The back of the box round the axle is cast with a round-edged projecting lip BB. A plate of metal CC, with a centre hole fitting the axle, is secured by bolts to the back of the box, with a piece of leather DD, the orifice of which is enlarged into a partial pipe form round the axle, to give increased bearing surface. This leather presses equally on the axle and on the lip of the box, and thus a tight joint is maintained, which preserves the grease without overflowing above the level of the bottom of the axle. The bolt-holes in the metal plate are oblong vertically, so that when the upper bearing brass wears and causes a corresponding wear in the plate and leather, and a consequent leak below, the two latter may be drawn upward to fit the lower part of the axle. At the top of the box there is a screw tap E for feeding, with holes through it to admit the ingress and egress of air. This tap serves to feed an upper chamber F, with holes to the axle as usual, and also to feed the lower chamber G, which in addition catches the grease that falls through from the upper chamber by the working of the axle. A piece of hard wood H is applied between the end of the axle and the front of the box, to prevent wear of the shoulder collar of the bearing brass. Two rollers of light wood, II, float on the oil or grease in contact with the lower side of the axle, and thus carry up the lubricating material if it happens to be below the level of the axle.

Figs 3 and 4 are a longitudinal section and back view of an axle and axle-box, also for an upper and lower feed. To retain the grease or oil, a conical metal spring CC is inserted in a corresponding circular groove at the back of the box; by its elastic expansion it presses against a strip of leather lining the groove, and thus forms a tight joint. The small end of the conical spring clips a leather pipe-collar DD, fitted on the axle, which collar may either revolve with the axle in the small end of the spring, or it may be fixed to the spring and the axle revolve within the leather collar; as the spring expands against the

groove in the box, it has no tendency to press the axle or leather too tightly, so as to cause friction. The conical spring is prevented from turning by a stud; the edges of the spring overlap each other to keep out dirt, and the hollow space between the spring and the axle may be filled with sponge or cotton waste.

Figs. 5 and 6, Plate 12, show a longitudinal section and back view of an axle-box on a similar arrangement, in which a conical pipe of blocked leather CC, is secured to the box lip by an elastic ring DD, similar to a key-ring, and clipped to the axle by a second ring EE. Both the spring cone and the leather cone will by their free action accommodate any irregular movement of the box, and prevent loose wear between both them, the metal plate, and leather. In all cases where any material comes in contact with the revolving axle, it is essential that the surface be properly smoothed, that the pressure be as light as may be convenient, and the lubrication certain.

Fig. 5, in addition to the axle-box arrangement, shows a mode of applying moveable journals to axle-arms, either new or old. Thus the journal AA, may be forged down to a taper, with the object of extending the distance of the bearing from the wheel, or of increasing the diameter of the axle-bearing. The moveable bearing BB, may be of wrought-iron, or cast-iron well got up and case-hardened; and manufacturers might be enabled to supply a superior class of axle-box and bearing cheaply. Railway Companies might thus be enabled, at comparatively little cost, to replace their axles when rendered unsafe by long vibration in running. The hollow axle, shown at Figs. 7 and 8, would be well adapted to this arrangement.

Great numbers of these boxes, with leather collars, have been applied, and have been found to answer the desired purpose.

It should be remarked that it is desirable in all cases to get the axle-bearings as long as is convenient, even when not required for bearing surface, for the following reasons:—The points of the springs which support the frames are at a considerable elevation above the axle-bearing, and act with mischievous leverage to tilt the axle-boxes laterally to the carriage, when the wheel flanges strike the rail. It is evident that unless there be some proportion in the length of bearing to the

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height of the spring, there will be a great strain upon the guards of the axle-boxes to keep them steady.

The axle box described above is the first application of the principle of retaining the grease or oil, by closing in the back of the box.

Since the above described, similar contrivances have been brought out by various other parties for the purpose of retaining the grease in the axle-boxes, but it appears that the original application of the principle was that of the writer, in May, 1847; and there does not appear to be any material variation in any of the subsequent plans.

As to the practical mechanism for keeping out dirt and preserving the bath of grease, it must vary with circumstances. Many axle-boxes are so close to the wheel bosses, that the leather pipe collar is the only practicable arrangement, and having come into general use, it is difficult to vary, but the writer prefers the elastic metal collars, CC, shown in Figs. 3 and 7, pressing upon leather pipe-collars DD

The object sought is to form a tight joint between the box and the axle, which are both exposed to rough jolts and a tilting movement of the box on the axle; therefore the medium to form the joint should be flexible, and not liable to be put out of order.

The mode of lubrication from above the bearing has one objection in the liability to accident by dirt getting on the arm, and from the holes wasting a most important part of the bearing surface; but the writer thinks it preferable to retain it, keeping the holes small, but merely as a security in case of any accident happening to the lower reservoir.

Two forms of journal are shown in the diagrams; one the double cone, Figs. 5 and 7, the other the ordinary cylindrical journal with collars, Figs. 1 and 3. There is an advantage in the double cone with the small diameter in the centre of the bearing, that it has a tendency to cause the lubricating fluid to press outwards from the centre while in rapid motion. The cylindrical bearing between collars has also this disadvantage, that the box is not kept in its position by gravity, but by a very small collar surface, which being vertical does not retain the lubricating fluid so easily as the horizontal surface; and, moreover, by its larger diameter has a tendency to throw it off by centrifugal action. Where the boxes fit tightly to the guards, the collar-bearings are frequently subject to rapid wear, and lateral

thrust is more destructive than the downward pressure of the load. The small rounded corners next the collars, intended to prevent the "nicking" or breaking of the axle, are of little service to give the box a centripetal tendency. The cylindrical bearing has the advantage, that the bearing surface is not lessened by end play, and with the axle working in a bath of lubricating material, the collars will at all times be safe enough. In either case, of the cone or the cylinder, it is clear that the lubricating bath below will be the safest precaution against heating. As regards the strength of the axle, the coned journal has the advantage by its gradual tapering form, supposing an equal amount of metal in both cases. The fitting of the wearing brass to the journal is a matter of greater nicety with the cone than with the cylinder; with cylindrical journals the usual practice is to make the bearing brass of considerably larger radius than the journal, so that it bears on a very small surface, which wears to a polish, and gradually extends to the half diameter. In point of fact, railway bearings are made to grind themselves to a true fit or work, instead of being accurately ground and fitted beforehand, as is the case with nicer machinery.

The Chairman inquired what comparative results were obtained as to consumption of grease in the axle-boxes tried on the North Kent line?

Mr. W. B. Adams said he understood that the axle-boxes worked very satisfactorily, and with a reduced consumption of grease, but he was not able to give the results of the economy, as an exact comparison had not been made.

The Chairman observed that there appeared some difficulty in the conical spring proposed, for the purpose of making a close joint between the box and axle, and inquired whether it had been found to have sufficient elasticity to work well?

Mr. W. B. Adams said that the only plan which had been practically tried, was the leather collar first described; he had not yet applied the conical spring, because there was not in many cases space enough to get it in between the axle-box and the nave of the wheel,

and therefore the leather collar only had been used, which had the advantage of taking up less space; but he thought the conical spring was preferable, and would make the most perfect joint, and there would be no difficulty in adopting it in modern carriages, as the projection of the axle from the wheel is now commonly extended to increase the width of the bearing.

The Chairman inquired how the grit was found to be kept out in Mr. Allan's Sponge Axle-Box, that was described at the last meeting?

Mr. Allan said that his axle-box was designed for using oil instead of grease; the only way dust and grit was kept out was the proximity of the nave of the wheel to the face of the axle-box, but it was found that the sponge prevented the grit from penetrating more than a short distance, about an inch or an inch and a half along the journal, as shown by the sponges when taken out.

Mr. E. A. Cowper remarked, that it was an important desideratum to get a grease-tight joint at the back of the axle-box, that would effectually keep out the grit, and not be interfered with by wear and the motion of the box; and he thought that such a joint had yet to be accomplished. In the American Axle-Box described at a recent meeting, the leather flange working in a groove on the axle, appeared a simple means for attaining this object, but some elastic provision for following up the wear was also wanted; this was proposed to be effected by the conical spring, though that plan might admit of further improvements, as there was generally very little room between the wheel and the axle-box.

Mr. W. B. Adams thought that some good plan was certainly much wanted, for efficiently closing the back of the axle-box, and there was not such a one in use at present; he thought the three or four inches space now usually left between the nave and axle-box, would be sufficient for the introduction of the proposed conical spring.

The Chairman observed, that it was a very important point to get the grit thoroughly shut out, and a good combination might perhaps be made of some of the plans that had been proposed for the purpose; any experiments on lubrication were interfered with in the results by the entrance of grit.

Mr. W. B. Adams remarked the difficulty of making exactly parallel experiments on the lubrication of railway axles, from the number of disturbing circumstances, in the variation of weight and uniformity of bearing on the journals, and in the attention to the lubrication, and the difficulty of getting the exact mileage.

Mr. Lea suggested the experiments to be made at the same time on opposite sides of the same carriage, so as to have them under similar circumstances.

The Chairman said he hoped Mr. Adams would pursue the subject, and give them further results; and he proposed a vote of thanks to him for his Paper, which was passed.

The following Paper, by Mr. John Lea, of London, was then read :—

ON A NEW LUBRICATING MATERIAL.

Whilst extensive and valuable improvements have been made in the construction of the locomotive stock of Railways, but little progress has been made in economizing the cost and improving the efficiency of lubricating the numerous moving parts of this extensive property. Since the first establishment of Railways, scarcely any change has been effected in the character of the materials employed for this important purpose ; oil and tallow were originally adopted, and are still almost universally employed in the more important department, the lubrication of locomotive Engines, to which department the subject of the present paper has more particular reference. The more limpid lubricating materials are wanting in consistency to resist pressure, and the more solid fats want fluidity to make them available under ordinary temperatures. The varieties of oil have, consequently, been at all times the common resource ; but even the majority, if not all of these want the perfect properties requisite for faultless lubrication.

Both animal and vegetable oils of every kind contain native impurities which materially qualify their efficiency. Many of them contain earthy matter, which soon becomes converted into a viscous, impeding, and exciting substance, of such consistency that produces

rapid abrasion of metallic surfaces, and consequently, causes such increase of temperature as seriously tends to disintegrate or soften the metallic body. All oils contain more or less of watery particles, which produce oxidation of the necessarily polished surfaces of the motive parts of machinery, and thus gradually wear them away, whilst the fluid itself becomes vitiated by its own action. As a further characteristic, it may be observed, that those oils most in repute as lubricants, are of such limpid consistency, that they become inevitably extensively wasted by escapement. The desideratum, therefore, for this important purpose, is clearly, some agent which shall possess all the necessary properties of smoothness and body, with adequate fluidity, and without the impurities and other defective characteristics of raw oils.

The new lubricating compound that is the subject of the present paper, is composed of carefully refined southern whale oil as a basis, to which are added India-rubber and levigated white and red leads, to constitute a kind of metallic soap, possessing the necessary oleaginous lubricating property, adequate fluidity, and a body impenetrable by the pressure upon ordinary bearings. The oil is heated to from 400° to 500° Fahr., and India-rubber cut up fine is then added, to the amount that the oil will dissolve, less than 50lbs. per ton of oil being sufficient; after the oil has become completely saturated with the India-rubber, the temperature is considerably reduced, and equal proportions of finely powdered red and white lead are added, at the rate of about 25lbs. of each per ton of oil.

The mineral ingredients perform the office of "vulcanizing" the compound, and presenting in use, a microscopic non-conducting stratum of separation of the bearings, which precludes friction, and consequently, heating and dissipation. In using the term "vulcanizing" it is intended to express the property of resisting any material change of consistency through any ordinary range of temperature, and it is found that the consistency of this compound does not observably alter through the extreme range of our English climate.

If there be no metallic contact between two surfaces, there can be no friction between them, and consequently, no elevation of temperature; and in the absence of undue heat there will be no excessive dissipation of the lubricating material, by volatilization. In the experiments made with this compound, it has been found that no pressure of bearing, or extreme of velocity, ever penetrated its substance, or produced any perceptible rise of temperature, and though it is gelatinous and as smooth as oil, its elastic body prevents penetration or displacement. It works freely with ordinary worsted or cotton syphons when the Engines are in motion, but ceases to flow when they are stopped, avoiding the waste of continuing to flow, to which limpid oils are liable. All the experiments made with the new compound under similar conditions have resulted uniformly, and it may be sufficient to quote in detail, an experiment made on the Manchester and Crewe Station of the London and North Western Railway. In this instance the new compound was applied to one of the Express Engines, (No. 15,) and another Engine, (No. 8,) of similar character, and performing equal daily service, was submitted to a careful comparison with Oil and Tallow. These experiments were continued over many weeks, and the following results were reported by the Engineer.

It has to be observed that the prices of oil and tallow were not then materially different to their present cost, but the quoted price of the new compound has been since reduced to one half. The distance run by the Engines in these experiments was about 2340 miles each, in the eighteen days referred to; the cost of oil and tallow was found to be nearly *Fourpence per journal*, per 1000 miles, whilst that of the new compound was scarcely more than *one Penny* for the same work, and would be at the present reduced cost only *one Halfpenny per journal, per* 1000 *miles*. This new compound is considered to possess lubricating properties much superior to those of any other natural or manufactured article, involving, as it does, remarkable efficiency combined with economy of cost; and it has the important advantage also of only requiring to be supplied at long intervals, thus preventing almost the possibility of accident arising from the exhaustion of the supply in the course of any single journey.

The author of this paper recently obtained from a number of Railways statements of their average cost of lubricating locomotive engines and tenders, and the general result showed an average cost of about *one Shilling* per journal per 1,000 miles, the range of cost being very limited, as none exceeded fourteen pence per journal for that distance, nor is any under eleven pence, including in all cases the lubrication of the other parts of the machinery, besides the axle journals.

Mr. Lea exhibited a specimen of the lubricating composition, and explained that the India-rubber, the ingredient on which its qualities mainly depended, caused the dark colour, and the composition was made of different degrees of thickness, to suit the different kinds of bearings, by varying the proportion of the red and white lead. In the manufacture of the composition the oil took up only a limited portion of the India-rubber, which was soaked in it whilst at the boiling point; the red and white lead were then added, simply in mechanical mixture, and thickened the compound to the degree required. He mentioned that the composition had been patented by Mr. Donlan, in 1848, but had remained dormant till the present time, when he, Mr. Lea, had taken it up.

The Chairman inquired whether there was any tendency to settlement of the heavier ingredients in the composition, and whether it was applicable to the ordinary oil cups, with syphon wicks.

Mr. Lea replied that no settlement was found to take place in the composition, after standing for some months; the thinner kind flowed as freely as oil in the ordinary syphon cups, and the thicker kind was adapted to the bearings of heavy shafting, and was found to keep them cool in cases where water was otherwise required.

Mr. Everitt inquired the effect of cold weather upon the composition, and what the expense of it was?

Mr. Lea said it was found to work as well in cold weather as in hot: the cost of it was Sevenpence or Eightpence per pound, but the proportionate quantity used was found to be considerably less than of oil or grease.

The Chairman proposed a vote of thanks to Mr. Lea for his communication, which was passed.

The following paper, by Mr. T. T. CHELLINGWORTH, was then read :—

ON MESSRS. COX AND WILSON'S PORTABLE SINGLE-ACTING STEAM ENGINE.

The subject of the present paper is a small Portable High-Pressure Steam Engine, differing from other engines of the kind, mainly, in the simplicity and economy of its construction, the small number of its parts, and the consequent diminished liability to derangement, and greater durability.

An engine similar to the present one was suggested some four years ago, by Mr. J. W. Wilson. It consisted of a solid plunger working in an oscillating cylinder, the steam acting only one way; the engine was partly drawn out at that time, but no further steps were taken, until the subject was again brought forward, recently, and a drawing was made by the author, who introduced the self-acting trunnion valves, as being more simple and less expensive than the slide-valve and gearing. One of these engines was made and set to work at the Oxford Works, in September, 1852, and has been at work ever since, and is now in as good order as the first day it was started, although running at an average rate of 150 strokes per minute.

This engine is shown in Plates 13 and 14, and one of the engines is exhibited on the table.

Fig. 1, Plate 13, shows a side elevation, with the trunnion in section.

Fig. 2, a front elevation, with the cylinder and trunnion in section.

A is the cylinder of cast-iron, bored out its whole length, the bottom screwed in, and the trunnions B and C cast on. In the trunnion C are the steam ports, shown in the cross section at D; the steam-way E connects the ports in the trunnion with the bottom of the cylinder. F is a cast-iron plunger packed with hemp and connected to the crank G; H H two A frames, I the fly wheel, L the steam pipe, K eduction pipe.

In Fig. 1, the engine is shown taking in steam, the plunger being at half stroke and the steam-way open; and in Fig. 4, the engine is

exhausting and the eduction port open. In the working of this engine, the steam forces up the plunger, the inertia of the wheel assisted by the weight of the plunger bringing it down. As it is single-acting, the pressure is always on the valve, working in fact like an ordinary slide valve, only on a curved instead of a flat surface.

This engine has worked with the cap of the trunnion plummer-blocks removed, without leaking.

Fig. 5, Plate 14, shows the general arrangement of the engine and boiler fixed on wheels, and Fig. 6, a section of the boiler. The boiler O, is set in a cast-iron box with fire bricks, the fire being under the boiler at P, and returning through the two tubes Q Q. R is the water gauge, consisting of a piece of tube working in a stuffing box; a cock is fixed on the side of the pipe with the end turning down into the tank S, from which the engine draws its water. When it is required to ascertain the height of the water in the boiler, this cock is opened, and if it blows steam the tube is pushed down till it reaches the water, if water, it is raised till it blows steam, and the level of the water in the boiler is indicated by the graduations upon the tube, forming a very simple and cheap water gauge.

The principal advantages claimed for this engine are, its simplicity of construction, and consequent cheapness, and the very slight probability of its getting out of order, even in the hands of an inexperienced person, together with its compactness and portability.

Some of the purposes to which it is proposed to be applied, are as follows :—

When placed with a boiler on wheels, as shown in Fig. 5, to be used in a factory where a number of machines are driven by a large engine ; now if it is required to do some overwork, in which, as is often the case, it is only necessary to drive one or perhaps two lathes, or other machines, this engine may with a very little trouble be wheeled up to its place and set to work, and the expense of running the large engine and shafting be saved.

Also, in repairing the large engine in case of a break-down, a great saving of time will be effected in not having the work done out.

For a donkey engine for feeding the boiler of marine and locomotive engines; and as a pumping engine for tank houses at Railway Stations, or other purposes. In this case it is proposed to place the pump in a similar position to the steam cylinder, but opposite, on the other side of the frame, and to work the pump by a crank, the two cranks being in opposite directions, so that the steam pressure acts to force the water.

It will be very applicable for small manufacturers and amateurs, &c., who may require a cheap and simple engine, and one not likely to get out of order.

This arrangement of cylinder and valves does very well for a force pump, the water being drawn through the steam pipe and forced out at the eduction pipe: in this case it is proposed to make use of it as a garden engine, or a small fire engine.

The governor that is proposed to be used for this engine, the invention of Mr. Wilson, is shown in Fig. 3, Plate 13, and consists of a cast iron or brass ball A, placed in the steam pipe B C, which at the governing point is tapered and curved upwards, as shown in the drawing, a stop being fixed at C to prevent the ball going so high in the pipe as to stick fast. The action of this governor is as follows: as the steam rushes along the pipe it carries the ball with it, which as it ascends, decreases the area that the steam has to rush through, and the higher it rises in the curve, the greater is this contraction, and the greater must be the pressure of the steam to counteract the force of gravity on the ball. The governor now exhibited has been applied to the ½ horse-power engine at the Oxford Works, and is found capable of regulating it so well, that when all the work is thrown off it will not allow the engine to run more than about 90 revolutions per minute.

Mr. Chellingworth exhibited one of the Engines of ½ horse power; also, the governor detached, to show the action. In answer

to a question, he stated that the cost of the engine exhibited was £10, and £18 complete with the boiler on wheels, as shown in the drawing.

The CHAIRMAN inquired whether the expense of working the engine had been tried?

Mr. WILSON said that the engine at the Oxford Works was supplied from the boiler of another engine, so that there was no means of ascertaining the consumption of fuel: the engine had been working constantly for six months, and had proved very useful and satisfactory.

Mr. E. A. COWPER observed, that he had seen the engine at work several times; it kept very fairly steam-tight, and he considered it would be usefully applicable to a great variety of purposes, on account of its being a very cheap construction and a good engine.

Mr. MIDDLETON thought the engine remarkably cheap, and a simple and convenient arrangement.

Mr. CHELLINGWORTH remarked that there were very few parts in the engine, only about a dozen separate pieces altogether. The engine was often worked very fast, from 150 to 200 revolutions per minute, and although so small, it was found very useful. It had drilled a number of 1⅛ inch holes in a large cylinder cover, 1¼ inch thick, in 4¼ minutes each. The surface of the valve was found to wear quite even, and after it had been at work a short time it appeared burnished, and had remained so.

The CHAIRMAN said he thought it was a very ingenious and simple construction of engine; and though it did not admit of the economy of working the steam expansively, yet the whole consumption could be only so small, as to make that point of little consequence, and he thought it would be found very useful and economical in many applications. He proposed a vote of thanks to Mr. Chellingworth, which was passed.

A Paper, by Mr. Andrew J. Robertson, of London, was then read, being a continuation of his former Paper—On the Mathematical Principles of the Centrifugal Pump.

(The publication of this Paper has been unavoidably postponed.)

The meeting then terminated.

After the meeting a variety of specimens illustrative of a new mode of ornamenting the surface of metals, were exhibited by Mr. R. W. Winfield and Mr. R. F. Sturges, of Birmingham; the process of the ornamentation being very simple, and consisting in placing a sheet of perforated metal or paper, thread lace, net, &c., between the two plates of metal to be ornamented, and then passing the whole through a pair of ordinary rolls, such as are employed for rolling metal; this produces a very clear, sharp, and even deep impression of the pattern employed upon the sheets of metal which it is desired to ornament. The depth of the indentation is such that the metal so ornamented can be subjected to the various operations of stamping, spinning, &c., for producing the manufactured article in its complete form, without any injury to the pattern; specimens of sheet steel were shown which had been ornamented with ordinary thread lace, and the delicate skeletons of leaves had left an impression on the surface of a copper-plate, from which engravings had been printed in the manner of the ordinary copper-plate printing, copies of which were exhibited.

Messrs. Salt and Lloyd, of Birmingham, also exhibited specimens of a new process for raising or stamping vessels, &c., formed from sheets of iron, tin, brass, &c., by which greater economy and rapidity are obtained than by the ordinary process. A heavy ram of 1¼ tons weight is raised by steam power a short distance of about a foot between guides, having the convex die attached to the under side of the ram, and the concave die or matrix is secured to the bottom of the frame as in ordinary stamping; the edges of the flat metal plate to be raised or stamped are then forcibly held down upon the matrix by a metal ring pressed down by eccentrics, whilst the blow is struck by the ram falling and driving the die through the ring into the matrix, which it fits accurately, the pressure of the ring on the edges of the metal plate being so adjusted as to allow the plate to draw uniformly into the required form without the edges becoming puckered; the metal is stamped cold.

PROCEEDINGS.

July 27, 1853.

The General Meeting of the Members was held at the house of the Institution, Newhall Street, Birmingham, on Wednesday, July 27, 1853, Samuel H. Blackwell, Esq., in the Chair.

The Minutes of the last General Meeting were read and confirmed.

The Ballot-papers were opened, and the following new Members were declared to be duly elected:—

MEMBERS.

Ralph Brown, Wednesbury.
Samuel Thomas Cooper, Leeds.
James J. Headly, Cambridge.
George Haden Hickman, Bilston.
Henry Maudslay, London.

The following Paper, by Mr. C. William Siemens, of London, was then read:—

ON AN IMPROVED GOVERNOR FOR STEAM ENGINES.

The governor of a steam engine has for its function to administer the supply of steam to the working cylinder in the ratio of the changeable load against the piston, the purpose of which is to obtain an uniform velocity in the engine. If it is the duty of the engine to impart motion to manufacturing machinery, the greatest possible regularity of motion is a desideratum of first importance, for it enables the manufacturer to work his machines at the

highest speed consistent with safety, and produce the largest quantity and a uniform quality of goods; it saves in personal attendance upon the machines; and, lastly, it increases the durability of the entire mechanism employed by preventing back-lashes and jerks.

The common (Watt's centrifugal) governor is notoriously imperfect in its action, being defective in principle in two respects.

1st—It cannot *regulate*, but only *moderates* the velocity of the engine; that is, it cannot prevent a permanent change in the velocity of the engine when a permanent change is made in the load upon the engine, and it can only *moderate* the extent of *permanent change in velocity*, because its influence upon the throttle valve depends on a change in the angular position of its weighted levers or pendulums, which change can only be effected by a permanent increase or decrease of the engine's velocity. And,

2nd—It cannot commence to act upon the valve until after the engine has undergone already a considerable change in its velocity, for at the instant when a portion of the duty is thrown on or off, the weighted levers are still in a state of equilibrium, and it is only by an accumulation of the fault, that they acquire a power to overcome the friction of the valve; to check the effect of the loss of time before the Governor begins to act on the engine, it then moves the valve to the opposite extreme, and a series of fluctuations will follow before the engine can recover a steady velocity.

Fig. 1, Plate 15, illustrates these defects in Watt's Governor. The dotted lines A A indicate the two extreme positions of the weighted levers in regular working, the one being at an angle of 25°, and the other of 35° from the axis. The corresponding extremes of velocity are inversely as $\sqrt{\cos. 25°}$ to $\sqrt{\cos. 35°}$, or as 905 to 952. The regular speed of the engine will, therefore, undergo a periodical change of $5\frac{1}{4}$ per cent. This is supposing that the pendulums are suspended from a point in the axis of rotation; but if, as is most frequently the case, they are suspended from points B B, removed some distance laterally from the axis, the change of speed will be nearly doubled, the length of pendulum being thus altered by the distance C C. The fluctuations which follow a sudden change of load will, however, far exceed those limits. Let

it be imagined that the engine is working at its medium speed, and that the Governor balls are revolving in equilibrium. Suppose a string to be tied between the two balls A A, of tensile strength equal to the resistance to the motion of the throttle valve. Let a portion of the load be thrown off the engine, and the velocity of its fly-wheel and of the Governor balls will gradually increase; but no alteration in the angular position of the balls can take place until their increase of centrifugal force suffices to break the string. The velocity will at this moment be proportionate to a much higher position of the levers than the adjustment of the valve D requires; they will, however, ascend into that position, and remain until the velocity of the engine has dropped sufficiently below its proper speed to accumulate acting power in the Governor in the opposite direction.

In practice, the defects of the Governor are ameliorated by personal attendance to the engine at such times when considerable changes in its load are expected to take place. In cotton and flour mills, for instance, the attendant on the engine is always forewarned of such changes by a bell, and effects the adjustment of the valve by hand.

Since the time of Watt, many attempts have been made to produce a more perfect Governor. Amongst them the Governor of Hick is the most remarkable, the regulating power of which depends on the rapidly increasing resistance, at increasing speeds, of the atmospheric air against rotating wings.

Fig. 2 and 3, Plate 16, is a diagram of this Governor. The two wings A A, are mounted upon a heavy boss B, containing a female screw, which is made to slide freely upon the threads of an upright male screw C; rotating motion being imparted to the latter by the engine, the wings will partake of the same until the resistance of the atmosphere against them equals the tendency of their entire weight to slide down upon the inclined threads of the screw. If the engine exceeds that velocity, the wings will rise and thereby shut the valve D, and *vice versa*.

It is apparent that it makes no difference to the speed of the wings, and consequently of the engine, whether the former are in

a more or less elevated position, and it follows, therefore, that this Governor is free from the first-named objection to Watt's Governor. It partakes, however, of the second, inasmuch as the resistance of the atmosphere is generally in equilibrium with the weight upon the inclined planes of the screw, and before either the one or the other can preponderate sufficiently to overcome the resistance of the throttle valve, it is necessary that the engine must have deviated sensibly from its regular speed.

Fig. 4, Plate 16, is another variety of Mr. Hick's Governor, which is remarkable for its simplicity and sensitiveness, although evidently less powerful than the former. The wings A A, are in this case made to revolve by the preponderance of one loose weight B, over another C, the engine being constantly at work on the shaft F to raise the heavier weight B, turning a second fixed pulley E; either of the loose weights is connected to the throttle-valve spindle D, so that the tendency of the heavier weight is to open the valve, while the engine is ever busy to close it.

Another variety of Hick's Governor was proposed a few years since, in which the wings themselves were shaped like portions of screws, and being free to slide upon straight keys on the driving shaft, were required to balance their weight by rotating under water, and so constantly tending to screw themselves upwards in the water.

The Pneumatic, or Cataract Governors, are a distinct group, of which a great variety have been proposed from time to time. The earliest is the cataract of the Cornish engine, by Watt. Heinrick's bellows Governor, Lariviere's and Pitchard's Hydraulic Governors, are other varieties, which, differing only in details, are represented by one diagram, Fig. 2, Plate 15. The pump A, is worked by the engine to force water or air below the weighted piston B, of a second cylinder or cataract, from whence it again escapes through a contracted aperture C, in a uniform stream. If the engine pumps more water than is discharged by that aperture, the weighted piston will rise and close the throttle valve D by the lever E; if, on the other hand, it pumps less than the discharge amounts to, the weighted piston will sink and open the valve Abstracting the differences in the height of water column above the discharge pipe.

and the friction of piston, the Hydraulic Governor would be capable of effecting the complete adjustment of the valve. It may moreover be made sufficiently sensitive for ordinary purposes by adopting a comparatively large supply pump. It is, however, very liable to derangement, owing to the valves and pistons employed, which, if they become leaky or stiff, will greatly affect the speed of the engine, and necessitate frequent re-adjustment of the discharge orifice, according to the judgment of the attendant.

Plate 17, represents the "Chronometric Governor," which is dissimilar in principle to any above referred to. It is the joint invention of the author's brother, Werner Siemens, and himself, and has been applied to a considerable number of engines since the year 1845.

Plate 18, shows a subsequent modification of the Chronometric Governor, having the advantage of greater simplicity and strength over the former: the latter it is the principal object of the present Paper to place before the Members.

The Original Chronometric Governor, Plate 17, consists of two essential parts, namely, the Chronometer A B, and the Differential motion C D E, between the chronometer and the engine, by which the effect upon the valve is produced.

The differential motion is obtained by means of three bevil wheels, one of which E, is turned by the engine, the opposite one C, by the chronometer in the opposite direction, and the remaining one D, is geared into both, and is at liberty not only to revolve upon its axis, but also to follow bodily the motion of either the first or second wheel by changing its angular position, and thereby the position of the valve.

The Chronometer is required to possess the following properties:—

1st.—To measure the time by a continuity of motion, unlike the vibrating pendulum, which, as it were, deals it out in periods of seconds or other units.

2ndly.—To possess considerable momentum, or instantaneous power to overcome resistance, in acting upon the valve.

3rdly.—To admit of great fluctuations in its maintaining power, without suffering its speed to alter; and

4thly.—To derive its maintaining power from the engine, and yet be affected uniformly by the same in a similar manner as a clock derives its maintaining power from a falling weight.

The first and second conditions are fulfilled by a heavy conical pendulum A B, which if freely suspended by a universal joint F will complete one revolution in the time during which a vibrating pendulum of the same length would complete one double oscillation. The length of the conical pendulum must, however, be measured from the point of suspension perpendicularly to the plane A F, in which its centre of momentum rotates.

This length varies with the angle of rotation, and with it the time of completing one revolution in the inverse ratio of the square root of the length, or of the cosine of the angle of rotation.

It would be practically impossible to regulate the slight maintaining power required to such nicety that the pendulum would persist in a uniform angle, and if restrained its properties as a chronometer would be entirely sacrificed. A remedy, however, suggests itself, consisting in the application of a *break* I, which is put into action by the pendulum at the moment when it has reached its intended angular position; and, by absorbing the excess of maintaining power, beyond that sufficient to overcome the friction and resistance of the atmosphere, takes away its tendency to assume a still higher position. An undue depression of the pendulum is guarded against by having a greater maintaining power than would be absolutely necessary, the excess being continually absorbed by the break.

The maintaining power might be obtained by a falling weight acting by means of a cord upon a pulley, which might be attached to the wheel moving in concert with a pendulum. By an arrangement similar to that of Mr. Hick's second Governor, the engine might be made to raise that weight again continually.

The differential motion, however, offers a facility for obtaining the desired effect, by simply attaching a weight H to a horizontal arm upon the spindle of a throttle valve; this weight, by its tendency to fall, pressing the horizontal differential wheel against the teeth

of the upper and lower wheels, exerts a constant power, tending to accelerate the pendulum; while the engine, by moving the remaining wheel in the opposite direction, produces the effect of constantly lifting the weight by the rod G.

It will be perceived that the Chronometric Governor fulfils the two conditions which are essential to obtain the perfect and instantaneous adjustment of the valve of an engine; namely, its speed is not in the least affected by the position of the valve (or the load upon the engine), and in distinction to all other known Governors, its action is simultaneous with the occurrence of a change in the load of the engine, its differential motion being indeed the most delicate test which could be applied to detect practically imperceptible irregularities in the speed of the engine. If a considerable portion of load were suddenly thrown off an engine, the fly-wheel would gradually acquire an increased velocity, but since only about 1-50th of a revolution in the advance of the uniform motion would suffice to shut the valve entirely, the adjustment of the same is effected before a sensible fault can occur. This result is corroborated by numerous experiments, the entire load of engines having frequently been thrown off without being perceived in the engine-house.

The Chronometric Governor has been applied to a considerable number of engines, where the difficulty of obtaining sufficient regularity was very great; such as flour mills, oil, and saw mills, &c.; in some cases it has now been at work night and day for upwards of seven years, and continues to give satisfaction; in others it has been less successful, for want of that degree of care and attention which delicate mechanism requires. Its principle has been put to the utmost test by the Astronomer Royal, who has applied it to regulate the motion of the great transit instrument at Liverpool (which is moved by water power), and to an instrument recording by touch, and it has obtained uniformity of motion within one or two seconds per hour.

The delicacy, and more particularly the expense of the Chronometric Governor, have been serious impediments to its more general introduction, and it is with a view to remove these that the

new arrangement, as shown in Plate 18, is proposed. The differential motion of this Governor is quite similar to that of the former arrangement, being only strengthened by the addition of a second differential wheel F. The principal change is in the Chronometer, which consists of a fly-wheel A A, in four segments, which are separately suspended from the lower bevil wheel at B B, and are closely surrounded by a cast-iron casing K K.

The weight H on the valve spindle will, on the engine being started, accelerate the wheel until the centrifugal force of its segments exceeds their gravity, and causes them to proceed outward. They will at that instant touch the casing K, and revolving at considerable velocity, the friction will readily absorb the excess of maintaining weight applied.

The principal feature of this Governor is its great power of action upon the valve, which renders it applicable to work variable expansion valves, or the floodgates of water wheels, without intervening secondary mechanism. At the instant when a change of load occurs, the power is indeed only limited by the strength of its rods and levers, because no amount of resistance could *suddenly* alter the velocity of its segmental fly-wheel.

It has further been ascertained by experiment, that this Governor will permanently support a weight of 1½ cwt. on the horizontal lever of the throttle valve: it possesses, moreover, the advantage of acting when placed in a slanting position, one having been placed, indeed, with its axis horizontally, instead of vertically, which continues to act well after several years' service; this Governor is thus rendered applicable to marine engines. Its great power would also enable it to act upon the lever of Woodcroft's screw propeller, with variable pitch, which it would regulate so as to maintain the engine at a uniform speed, independently of the speed of the vessel.

In the application of this Governor to engines, it is important to give it the sole and entire command over the admission of steam. For this purpose the throttle valve of the engine should be more perfect than those commonly applied. The valve shown in Plate 18 is preferred, inasmuch as its spindle is relieved from the pressure of the steam, which is made to enter from opposite sides

at I I. The connection between the Governor and the valve should, moreover, be made as direct as possible, and the maintaining weight be attached to the lever immediately upon the valve spindle, in order to prevent loss of motion.

Several Governors of the improved construction have been put up by Messrs. Hick and Son, of Bolton (one to an engine on their works,) and have proved practically successful during upwards of nine months of trial.

Mr. SIEMENS exhibited a working model of the improved Chronometric Governor, and explained its action: the drawing shown was about the size of a Governor suited to a 30-horse power engine, which would have a revolving weight of about one cwt.

Mr. SLATE thought the new Governor a very important and valuable addition to the steam engine, and that it completely removed the defects of the old Centrifugal Governor, which might be almost said to be the only imperfection left by Watt in the steam engine. He inquired whether any comparison had been observed of the breakage of threads that occurred in spinning machinery when the improved Governor was used in place of the old one, showing the comparative economy in manufacture produced by greater steadiness and uniformity of motion?

Mr. SIEMENS replied that the chief advantage was found to be in the increase of work done by the same machines, in consequence of the nearly absolute uniformity of motion enabling them to be driven at a higher speed. With the ordinary governor the fluctuation in speed could never be less than 5 per cent., and was practically considerably greater, and as the maximum speed had to be set at the limit allowed by the manufacture, the mean speed of the machines was consequently so much below; but the new governor allowed the maximum speed to be adopted constantly, as the motion was practically quite uniform, and no fluctuations were perceptible. There had been more experience of the results in flour mills at present than in cotton mills; and in those cases the new governor was found to do away with the constant attendance of spout-men, who are ordinarily required to regulate the speed of the stones by

hand, according to the variations in the quality of flour produced, depending on the speed, and the quality of the flour was found to be enhanced by the perfect uniformity practically attained in the speed; the quantity of work was very considerably increased by the certainty that the governor afforded of maintaining constantly the maximum speed required.

Mr. Slate inquired whether any difference had been observed in the detérioration and wear of the gearing, from the speed of the wheels being kept quite uniform?

Mr. Siemens replied, the new Governor had always the effect of entirely taking away the back-lash between the teeth of the wheels, by keeping all the machinery at an invariable speed; this must diminish the wear of the teeth, but it was difficult to obtain any correct return of the separate economy from this cause.

Mr. McConnell asked what was the time required for the correction of the velocity, when a large proportion of the load was suddenly thrown off, such as 3 or 4 pair of stones in a flour mill?

Mr. Siemens said the correction was almost instantaneous, even when the whole of the load was suddenly thrown off, as the engine could only make a very small portion of a revolution before the governor shut off the whole of the steam if necessary. He might mention in illustration a case where he was trying experiments on the efficiency of the governor with Mr. Field and other gentlemen, and the whole of the load of a 30-horse power engine was suddenly thrown off, and then put on again after some minutes, but Mr. Field, who was in the engine-house timing the engine, did not perceive any change in its speed.

Mr. McConnell observed it would be the perfection of the action of a governor to maintain the teeth of wheels always in contact on the driving side and prevent any back lash. The new form of the governor was a great improvement for practical application, though the use of four bevilled wheels instead of three gave a more complicated appearance than in the original form of the Governor. He inquired whether it was found to increase the wear and the difficulty of keeping in order?

Mr. Siemens said the new form of the governor was really as simple and not more expensive than Watt's Governor for the

same power of engine; the fourth differential wheel added very little to the expense, and removed the wear of the spindle, by balancing the pressure on both sides. Also, the governor itself never varies its velocity, so that there was no varying in the speed of the different parts, to cause unequal wear or strain, as was the case in the ordinary governor. The original form of the Chronometric Governor was more theoretically correct, but the small surface of the point of the spindle to receive all the pressure involved more care in oiling and keeping clean than could be depended upon from some of the rougher hands having the charge of engines; but in the cases where they were properly attended to, they had kept in perfect order during seven years' constant work, the spherical ball acquiring a fine polish. The present improved form of the governor was quite free from this difficulty; the friction segments were left entirely without oil, as the pressure was too small to cause injury from want of oil, and the use or absence of oil did not affect the correct action of the governor, so that no source of inaccuracy could arise from accidental want of attention.

The Chairman inquired whether the original governor was still employed by the Astronomer Royal to regulate the motion of astronomical instruments?

Mr. Siemens said that it continued in regular use for that purpose with entire satisfaction. It was peculiarly advantageous for the touch record instrument, consisting of a uniformly revolving drum, divided into minutes and seconds, on which the moments of observations were recorded by the touch of a pencil; the accuracy entirely depended on the absolute uniformity of the revolution of the drum, and this was previously liable to derangement from the variations in the resistance caused by variation in the pressure of the pencil, and the interval and time of its contact, but a perfect uniformity of motion was obtained by the action of the Chronometric Governor, by providing an excess of maintaining power above the maximum disturbance, the surplus being always absorbed by the friction of the break; with the transit instrument at Liverpool, the governor acted on the sluice of the small water wheel driving the moving apparatus, which amounted altogether to some tons weight.

Mr. C. Cowper inquired whether there was any means of altering the rate of speed of the engine if required, with the same governor?

Mr. Siemens thought it was not advisable to allow the means of altering the speed, as all machinery worked and kept in order best when it was maintained uniformly at the rate of speed for which it was calculated. But if necessary a change of speed could be readily obtained by employing a conical speed-pulley to drive the governor; the governor will always keep at the same absolute speed, but the engine may be set to run at any relative speed by proportioning accordingly the intermediate pulleys or gearing.

Mr. Clift inquired the effect of wear on the rubbing surfaces of the friction ring, whether they required renewal, and whether the wear affected the accuracy of adjustment of the governor?

Mr. Siemens explained that the only rubbing surfaces were the ends of the four steel pins, one in each of the segments; which were slightly rounded at the ends, with springs behind them to allow for wear; but the wear was exceedingly small, even in those of the first kind, which had been seven years at work, it was quite inconsiderable.

The Chairman asked how long the new form of Governor had been practically tried by regular work?

Mr. Siemens replied it had been in use about nine months.

Mr. Charles May said he had had the first form of Mr. Siemens' Governor in constant use for several years, with entire satisfaction; he was one of the earliest users of them, and had three in use at once, and he had never ceased to consider this governor as one of the greatest accessories to the steam engine. He thought it would be particularly useful in the iron districts, where the power required in driving the rolling mills and forge hammers was subject to such frequent and violent fluctuations; the rapidity of action of this governor was so great, that it might be said to adjust the throttle valve whilst the ordinary governor was thinking about moving. There were difficulties in some of the first applications of the governor, arising from prejudices, and particularly from defect of the throttle valves, which were often very inefficient; but he could bear testimony to its complete success

when properly applied. In one case of its application he had an engine of 50 indicated horse-power, sawing up 16-inch baulks into sleepers, where the work came on and off suddenly with the saw cut, but the engine making 35 strokes per minute did not vary anything like 1 stroke per minute, though with an ordinary governor there would probably have been a variation of 10 strokes per minute with the same work.

The CHAIRMAN expressed his opinion of the great practical utility of the new governor, and thought its application might be advantageously extended to the engines of iron works and steam boats.

A vote of thanks was passed to Mr. Siemens for his paper.

The following paper, by Mr. J. E. McConnell, of Wolverton, was then read:—

ON HOLLOW RAILWAY AXLES.

The subject of Railway Axles was brought before the Institution on a former occasion by the writer, when he gave the result of various experiments, showing the form and dimensions most economical of material, with a proportionate and proper strength of the several parts, and also the changes in the structure of the iron which appeared to have taken place from various causes during the course of working. Since that period the writer's attention has been constantly directed to the subject, and the opinion he then expressed respecting the fractures of axles arising from changes from the fibrous structure of the iron, to a brittle, short-grained, or crystalline condition, has been confirmed by repeated instances which have come under his knowledge.

With the view of improving the strength and durability of Railway Axles, the two most important points for insuring the safety and security of railway travelling, the writer, after repeated experiments, and obtaining all the experience and information he could collect on the subject, arrived at the conclusion that the hollow or tubular axle combined in itself, if properly manufactured, all the properties necessary to secure the best form for lightness, strength, uniformity of structure in the material, elasticity to neutralize the injurious effect of blows and concussions, and conse-

quent durability, from having a greater freedom from deteriorating effects.

The selection of the tubular form of axle originated from the knowledge, that with a considerably less weight of material in the form of the tube, a much greater strength can be obtained to resist torsion, deflection by pressure or weight, or concussion from blows. The resistance of a solid cylinder to deflection and torsion, increasing in proportion to the fourth power of the diameter (or the square of the square), but the weight increasing only as the square of the diameter, two solid cylinders, having the respective diameters of 4 and 5 inches, or 1 to $1\frac{1}{4}$, will have a proportionate weight of 16 to 25, or 1 to $1\frac{1}{2}$, but a resistanceof 256 to 625, or 1 to $2\frac{1}{2}$. Then if a hollow of $\frac{2}{3}$rds the diameter be made in the larger axle, its weight will be diminished $\frac{1}{2}$, ($\frac{2}{3} \times \frac{2}{3} = \frac{4}{9}$ or $\frac{1}{2}$ nearly,) and its resistance only 1-5th, ($\frac{2}{3} \times \frac{2}{3} \times \frac{2}{3} \times \frac{2}{3} = \frac{16}{81}$, or $\frac{1}{5}$ nearly), and the comparison with the smaller solid axle will then be 1 to $1\frac{1}{4}$ in diameter, 1 to $\frac{7}{8}$ in weight, and 1 to 2 in resistance, being double the resistance, with $\frac{1}{8}$th less weight.

The use of Hollow Axles was tried some years ago, but was not continued, the main objection being that there appeared a great difficulty of insuring, by the particular mode of manufacture adopted at that time, a sufficient uniformity of thickness of the sides of the tube throughout, and also of the soundness of material. The mode adopted consisted of rolling two or three bars of a semi circular cross section, which were welded together with butt joints, but with no internal pressure, and with solid ends where the bearings came. These axles, having no maundril or internal pressure during the process of welding, were found to be of a very uncertain strength throughout the axle, and the weakest point might be close to that part where the greatest force or strain would be exerted.

To overcome these objections, a mode of manufacturing Railway Axles has been introduced by the writer, which it is believed effectually accomplishes the objects in view, securing the utmost strength with the least possible amount of material, uniformity of structure of the iron, perfect equality of thickness of material, and soundness of manufacture.

The plan adopted is as follows :—A number of segmental bars of the best quality of iron are rolled to a section, as shown in Fig. 5, Plate 19, so as to form, when put together ready for welding, a complete cylinder Fig 6, about 1½ times the diameter of the axle when finished as Fig 7, the bars fitting correctly together, so as to have no interstices, and overlapping in such a manner as to insure a perfect and sound weld when completed, as shown in Fig 6.

This cylinder of loose segmental bars is temporarily held together by a screw clip, and each end being put into the furnace until a welding heat is produced, the bars are then partially welded together and the clip removed. The whole cylinder is then placed in the furnace, and brought to a proper welding heat; it is then passed through a series of rollers, BB, Figs. 1 and 2, Plate 19, which have each a maundril of an egg form, A, in the centre of the circular openings, which are attached and supported on the end of a fixed bar, the fixed bar being firmly secured at the opposite end, to resist the end pressure or strain during the process of rolling. The maundrils are made of cast-iron, chilled, fitting on like a socket on the end of the bar to a shoulder, and they are secured by a screw nut, so that they are easily removed when required.

The motion of the rolls is so arranged, by a reversing clutch on the shaft, that as soon as the axle cylinder has been drawn clear through, the motion is reversed, and the axle, which has been drawn on to the maundril rod, is again drawn back through the same opening in the rolls; it is immediately passed through the next smaller groove of the roll with a decreased size of maundril, and again reversed back through the same groove in a similar manner, and so on through a series of grooves in quick succession, each decreasing in size, and consequently increasing the compression and strength of the iron of which the axle is formed, and by the last groove it is passed through it is reduced to the proper diameter. At each time it is changed from one groove to another, the axle cylinder is turned by the workman a quarter round, so as to equalise the pressure on every part of its surface, to insure uniformity of the compression of the iron, and thoroughly complete a sound welding throughout every part of the axle.

The specimens before the meeting will show the soundness and

perfection of the manufacture, as a proof of which, in every test applied, either by blows on the outer surface, or by an immense splitting pressure, by driving a maundril in the interior, there has never been found in any one instance a failure of the weld, although the test has been applied to pieces cut off the extreme end, where it might be supposed the welding of the cylinder of the axle from various causes would not have so good a chance of being perfect.

The axle at this stage, after being welded and drawn down in the rolls to the size in Fig. 3, is taken at once to a hammer, where it is planished between semi-circular swages over its entire surface. A small jet of water plays upon it during this process, which enables the workman to detect at once, by the inequality of colour, any unsoundness in the welding. From the hammer it is taken to the circular saws, where it is cut accurately to the length required, and ready to have the bearings formed upon it.

On coming from the hammer the axle is found to be perfectly clean both inside and outside, the scale being entirely removed. The ends are then re-heated, and gradually drawn down by a hammer to the proper dimensions and form of the journals, as in Fig. 4, a maundril being inserted in the end of the tube during the process of hammering.

The formation of the journals can also be produced by a rolling machine, constructed of tables the entire length of the axle, rolling transversely, each table being a duplicate of the other, and matrixes of the axle when finished. Or in another way, by two sets of rollers, each set consisting of three rollers running vertically, being of the same diameter, and driven at the same velocity, formed exactly to the shape of the bearing, and set the proper distance apart from shoulder to shoulder of the journals.

The manufacture of these axles has been entrusted to the Patent Shaft Company, and a great amount of credit is due to Mr. Walker, the managing partner of that firm, for the very excellent system he has adopted and carried out in the process of manufacture.

There can be no doubt that the Hollow Axles, as now manufactured, are much superior to any yet produced.

As an illustration of the saving in dead weight, take for instance a railway employing 15,000 waggons and carriages, and assume each of these vehicles to run on an average 10,000 miles per annum. The weight of two axles of the solid description finished, say 5cwt., and if replaced with Hollow Axles of equal strength, the weight per vehicle may be reduced 1½cwt.; this taken over one mile of the above stock per annum will be 11,250,000 tons, and assuming the cost of traction for locomotive power at ¼d. per ton per mile, the saving will amount to £11,700 per annum, without taking into account the other advantages, and also the saving to the permanent way, &c.

In the samples of axles submitted to the meeting, two different kinds of bearings are shown, the parallel bearing with the rounded shoulder, Fig. 8, Plate 19, and also the double conical bearing, Fig. 9, such as is used on the Great Northern, Great Western, Bristol and Exeter, South Wales, and South Devon Railways. In either description of bearing the Hollow Axle is good, although it is believed that the conical bearing for *either* the Solid or Hollow Axle has a less tendency to injure the texture of the iron during the formation of the journal than the parallel shouldered axle, and it appears a matter well deserving the consideration of this Institution, to ascertain what, under all conditions, is the best form of axle bearing.

The following experiments, conducted by Mr. Marshall, the Secretary of the Institution, have been tried for the purpose of ascertaining the comparative strength of the hollow and solid axles to resist a transverse strain :—

Each axle was supported on massive cast-iron blocks, fixed at a distance of 4ft. 11in apart, to represent the support given by the rails to the axle A cast-iron block weighing 18cwt. was then let fall on the centre of the axle from a height of 12 feet, and the extent of bending was measured. The axle was then turned half round, and another similar blow given on the opposite side, bending it in the opposite direction. This proceeding was repeated until the axle was broken, and the particulars of the number of blows and amount of bending are given in the accompanying Table, No. 1.

The general results of these experiments are as follows :—

An *Old Solid Axle*, G, 3¾ inch diameter in centre, and 4¼ inch at ends, which had been at work three years, was bent 8¾ inches by the

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1st blow; it was nearly straightened by the 2nd blow in the opposite direction, then bent 10 inches by the 3rd blow, and with the 6th blow it was broken in the centre square across.

A *New Solid Axle*, H, of the same dimensions, was bent 9¾ inches by the 1st blow, then nearly straightened by the 2nd blow, and bent 9½ inches by the 3rd blow, and by the 4th blow 2½ inches, and by the 5th blow it was broken ¾ inch from the centre.

The appearance of the fracture was crystalline over three fourths of the section, the remaining part tough fibre. This fracture is shown in Figs. 10 and 11, Plate 20.

A *New Hollow Axle*, I, 4⅝ inch diameter throughout, was bent 5 inches by the 1st blow, then nearly straightened by the 2nd blow, and bent again 5 inches by the 3rd blow. The 9th blow bent it 4½ inches, and the 10th blow 1⅜ inches. Up to the 15th blow it was bent alternately, the bends varying from 2 to 3½ inches. There was no appearance of failure or cracking, but a slight rising of the surface at the 15th blow. The blows were continued to the 27th, the bends varying from 2 to 3⅝ inches, and at this blow a fracture took place across the middle of the axle 1¼ inches long. The 28th blow bent it ⅜ inch, and closed the fracture on the opposite side made by the preceding blow. By the 29th blow it was fractured two thirds through, and bent 9½ inches, the appearance of the fracture being very fibrous. This fracture is shown in Figs. 12 and 13.

A second series of experiments was made, to ascertain the comparative strength of the journals of the hollow and solid axles to resist breaking.

Each axle was supported on an anvil, with the inner shoulder of the journal projecting 1½ inches beyond the edge of the anvil, to represent the support of the axle in the nave of the wheel; 100 blows with 24lbs. sledge hammers were then struck upon the upper side of the outer end of the journal, the men being changed after striking each twelve or thirteen blows alternately. The amount of bending of the journal was then measured, and the axle turned half over, and another 100 blows similarly given on the opposite side of the journal: the same proceeding being then further repeated, and the several particulars are given in the accompanying Table, No. 2.

The general results of these experiments are as follows:—

An *Old Solid Axle* with 3 by 5 inch journals, that had been at work three years had one journal, C, broken off with 205 blows, and the other, B, with 53 blows: both fractures were square across the journal at the shoulder.

A *New Solid Axle*, F, with 3 by 6 inch journals, had the journal broken off with 570 blows, the fracture being irregular in form, and fibrous. This fracture is shown in Figs. 14 and 15, Plate 20.

A *New Hollow Axle*, D, with 3 by 5 inch journals, had 400 blows on the journal, which bent down the end $\frac{5}{8}$ inch, and produced a longitudinal split on the under side, $3\frac{3}{4}$ inches long, but no transverse fracture.

A *New Hollow Axle*, A, with the same size journals, received 800 blows on the end of the journal, which bent it down $\frac{1}{8}$ inch, and split the journal longitudinally on both sides, but caused only a slight transverse crack near the shoulder, $\frac{3}{4}$ inch long. The fracture is shown in Figs. 16 and 17.

The experiments on transverse strength, by a heavy weight falling on the centre of the axle, and giving the blow on opposite sides alternately, show that the hollow axle is nearly double the strength in that respect of the corresponding solid axle, the amount of bending being only 5 inches instead of $9\frac{3}{4}$ inches, and the number of blows required to break the hollow axle being 29, whilst the solid axle broke at the 5th blow, shows the hollow axle to be greatly stronger in resistance to fracture.

The hollow axle became $\frac{1}{8}$ inch oval in the centre after receiving the seventh blow, and it was only $\frac{1}{4}$ inch oval after receiving the twenty-eighth blow just before fracture; being bulged outwards $\frac{1}{16}$ inch at each side, and $\frac{1}{16}$ inch inwards at top and bottom from the original circular section.

The experiments on strength of journals show that instead of the journals breaking off square and short at the shoulder, as in the solid axles, the hollow axle journals stand a considerably greater number of blows, and then only split up longitudinally, instead of breaking off transversely, being a very important advantage in point of safety in working.

TABLE No. I.

Experiments on the Transverse Strength of Axles.

(Axle supported at each end, 4 ft. 11 in. length between supports, cast-iron weight of 18 cwt. falling on centre of axle, blows given on the opposite sides alternately.)

Description of Axle.	No. of Blows.	Height of Fall. Feet.	Deflection in centre from straight line. Inches.	Total Bending by each blow. Inches.	Remarks.
G Old Solid Axle .... $3\frac{3}{4}$ in. diam. centre $4\frac{1}{4}$ in. diam. at ends	1	12	$8\frac{3}{4}$	$8\frac{3}{4}$	Crack on underside, 3 in. long, 1-16th in. open, an old flaw.
	2	10	$\frac{1}{2}$	$9\frac{1}{4}$	
	3	12	10	$10\frac{1}{2}$	
	4	$11\frac{1}{2}$	—7	3	The supports gave way laterally, reducing the force of blow, Axle bent upwards 7 in.
	5	$11\frac{3}{4}$	$1\frac{3}{8}$	$8\frac{3}{8}$	Blow on same side as the last, four small cracks on underside.
	6	12	—	—	Axle broken square across, 3 in. from centre, surface of fracture crystalline.
H New Solid Axle .... $3\frac{3}{4}$ in. diam. centre.. $4\frac{3}{8}$ in. diam. at ends	1	12	$9\frac{3}{4}$	$9\frac{3}{4}$	
	2	$11\frac{3}{4}$	$\frac{1}{4}$	10	
	3	12	$9\frac{1}{2}$	$9\frac{3}{4}$	
	4	10	$—2\frac{1}{2}$	7	Lifting chain broke at 10 ft. height, Axle bent upwards $2\frac{1}{2}$ in.
	5	12	—	—	Axle broken square across $3\frac{1}{2}$ in. from centre, surface of fracture, 3-4ths crystalline, 1-4th tough fibre.
I New Hollow Axle .. $4\frac{5}{8}$ in. diam. centre.. $4\frac{3}{8}$ in. diam. at ends	1	12	5	5	
	2	$11\frac{3}{4}$	$1\frac{3}{8}$	$6\frac{3}{8}$	
	3	12	5	$6\frac{3}{8}$	
	4	12	1	6	
	5	12	$4\frac{3}{4}$	$5\frac{3}{4}$	
	6	$11\frac{3}{4}$	$1\frac{1}{8}$	$5\frac{7}{8}$	
	7	12	$4\frac{1}{2}$	$5\frac{5}{8}$	
	8	$11\frac{3}{4}$	$1\frac{1}{8}$	$5\frac{5}{8}$	
	9	12	$4\frac{1}{2}$	$5\frac{5}{8}$	
	10	$11\frac{3}{4}$	$1\frac{3}{8}$	$5\frac{7}{8}$	
	11	12	$3\frac{1}{4}$	$4\frac{5}{8}$	
	12	12	$1\frac{7}{8}$	$5\frac{1}{8}$	
	13	12	$3\frac{1}{2}$	$5\frac{3}{8}$	
	14	12	2	$5\frac{1}{2}$	No appearance of failure or cracking.
	15	12	$3\frac{3}{8}$	$5\frac{3}{8}$	Very slight appearance of rising on the surface.
	16	12	$2\frac{1}{8}$	$5\frac{1}{2}$	No appearance of fracture on this side.
	17	12	$3\frac{1}{2}$	$5\frac{5}{8}$	
	18	12	2	$5\frac{1}{2}$	
	19	12	$3\frac{3}{8}$	$5\frac{3}{8}$	
	20	12	$2\frac{1}{4}$	$5\frac{5}{8}$	
	21	12	$3\frac{3}{8}$	$5\frac{5}{8}$	
	22	12	$2\frac{1}{8}$	$5\frac{1}{2}$	
	23	$10\frac{1}{2}$	3	$5\frac{1}{8}$	
	24	12	$2\frac{3}{4}$	$5\frac{3}{4}$	Some little appearance of rising on the surface.
	25	12	$3\frac{1}{4}$	$5\frac{3}{4}$	
	26	12	$2\frac{1}{8}$	$5\frac{1}{2}$	
	27	12	$3\frac{1}{4}$	$5\frac{3}{4}$	Fracture across centre of underside, $1\frac{1}{4}$ in. long.
	28	12	$3\frac{1}{8}$	$6\frac{3}{8}$	Closed the fracture on the opposite side.
	29	12	$9\frac{1}{2}$	$12\frac{5}{8}$	Axle broken 2 3rds through, split longitudinally 3 in., fracture very fibrous and irregular.

TABLE No. II.

Experiments on the Strength of Axle Journals.

(Axle supported at 1½ in. length from inner end of Journal, blows of 24 lb. sledge hammer on outer end of journal, each 100 blows given on opposite sides of the journal alternately.)

Description of Axle.	No. of Blows.	Total No. of Blows.	Deflection at end from straight line. Inches.	Remarks.
C				
Old Solid Axle	100	100	¼	Small crack at Shoulder.
Been 3 years at work	100	200	1⅛	Crack 1 inch open at Shoulder.
Journal 3 × 5 in.....	5	205	—	Journal broken off square at Shoulder, surface of fracture fibrous, partly crystalline
B				
Old Solid Axle, ... the other journal of axle C.	53	53	—	Journal broken off square at Shoulder, surface of fracture all crystalline.
F				
New Solid Axle, ...	100	100	¼	
Journal 3 × 6 in.	100	200	⅛	
	100	300	5/16	
	100	400	3/16	
	100	500	1/16	
	70	570		Journal broken off square at Shoulder, surface of fracture mostly fibrous.
D				
New Hollow Axle ..	100	100	—	
Journal 3 × 5 in.	100	200	1/16	
	100	300	3/16	Longitudinal split 2¾ in. long, 5-16 in. open, on underside.
	100	400	⅜	Split underside 3¾ in. long, ¼ in. open, no transverse fracture.
A				
New Hollow Axle ..	100	100	1/16	
Journal 3 × 5 in.	100	200	1/16	
	100	300	3/32	
	100	400	⅛	
	100	500	5/32	Split longitudinally 1 inch long.
	100	600	0	Cracked slightly obliquely.
	100	700	⅛	Split longitudinally 2½ in. long.
	100	800	⅛	Split longitudinally 4 in. long, small piece broken out at end, slight transverse crack at shoulder ¾ in. long.

Mr. McConnell exhibited a number of specimens of the axles tried in the experiments, and specimens of the hollow axles cut in two longitudinally, showing the thickness of metal to be quite uniform throughout the axle and journals. He also showed and explained an instrument used for measuring accurately the thickness of the metal at the shoulder of each journal, and in the journal after the axle was turned; it consisted of a double sliding gauge (see Figs. 18 and 19, Plate 20), one sliding part AA being inserted into the open end of the axle, and shaped to fit closely to the inside of the shoulder at C, and the other sliding part B fitting the outside of the journal and axle; the whole gauge was held steady on the body of the axle by the arm and clip DD. When the gauge was adjusted by a compound sliding motion so as to fit the axle inside and out, the exact position of the outer sliding portion B was marked by bringing a screw stop E in contact with it, and it was then withdrawn sufficiently to allow the gauge to be disengaged from the axle by drawing the inner slide out of the axle; the outer slide B was then brought back to its former position by sliding it home to the screw stop, and the space thus left between the edges of the inner and outer slides A and B gave a correct outline of the thickness of the metal, which was traced at once on paper. Each axle was examined in this manner and registered before it was sent out to work, so as to provide against any axle being turned out in an imperfect state from the journal being accidentally cut into the metal too much at the shoulder.

The Chairman remarked, that in the fracture of the hollow axle all the iron appeared fibrous, but the fracture of the solid axles was mostly crystalline.

Mr. McConnell said he had found the same differences in all he had tried: the iron of the hollow axle was as fibrous throughout as the best bar iron.

Mr. W. Mathews inquired what was the saving in weight of the hollow axles, and whether they had yet been applied extensively?

Mr. McConnell replied the reduction in weight was about 2-5ths theoretically to obtain the same strength, but it had been taken at ⅓rd of the solid axles, to be on the safe side. The hollow

axles were being extensively applied on the North.Western, Midland, and Great Northern Railways, and more than 500 had already been made; some had been at work for nine months with entire satisfaction.

Mr. W. MATHEWS asked what was the relative cost of the hollow axles, and whether any difference was found in the crystallising of the iron from the effects of working?

Mr. MCCONNELL said that no observations could be made on that point yet, and it would be difficult to arrive at any conclusion upon it, except from actual long work.

Mr. NORRIS observed that in the fractures of the new solid axles there was considerable variation, some parts being fibrous and other parts crystalline. He said he had tried many old axles that had been 20 years at work on the Liverpool and Manchester Railway, and none of them appeared crystalline on breaking off the journals, though several new ones were found to break crystalline; the new ones were about ¼ inch larger diameter in the journals. He doubted any crystallising effect being produced by working on the railway; he thought it depended more on the original manufacture.

Mr. SLATE remarked, that iron would be crystallised if overheated in the furnace, and the hollow axles might be injured in this way without proper care.

The CHAIRMAN said the most fibrous bar could be made crystalline in one part by overheating it.

Mr. CLIFT suggested that less heat might be required to weld the hollow axle than the solid one, on account of the reduced substance of the iron, which would be less injurious to it.

Mr. MCCONNELL observed, that in the case of the sling chains for holding up in forging large bars, and in other similar instances, the continued concussion was found to have the effect of making the iron break in a certain time quite crystalline, though it had been quite fibrous originally; this was known to take place so regularly, that the time of breaking was reckoned upon, and they sometimes lasted only a few months. In the hollow axle there was a different condition of the iron from the solid axle, as in the latter the iron in the centre was not so solid as the outside, because the pressure

was only applied on the outside, and the larger the bar the more this was perceived; but in the process of manufacture of the new hollow axle, in consequence of the internal pressure combined with the external, and the small thickness of the metal, the whole axle was made as solid as the outside of an ordinary axle. It had, in fact, two skins, one outside and one inside.

Mr. Slate remarked that the skin of iron was generally looked upon as stronger than the rest, but he doubted whether the skin was really of much importance to the strength, as it could only be a thin film of scale or oxide. He should like to see the experiment tried of a hollow axle bored out and turned so as to remove the skin, and expected it would be found to make little difference.

Mr. McConnell said the skin was important in cast iron, and the strength was considerably diminished if the skin was removed; he thought something of the same kind applied to wrought iron.

Mr. May hoped the experiment suggested would be tried; he thought the ordinary idea of the skin was a delusion, both in cast and wrought iron, and he believed there would even be found more strength per square inch in the area left if the skin were planed or turned off.

Mr. Duclos observed, that in cast iron the skin would be different in composition, assimilating to steel, and harder than the rest of the metal, if not stronger, according as it was more or less chilled, but in wrought iron the skin was mainly oxide of iron, and was really weaker than the pure iron.

Mr. Slate thought a cast-iron bar planed down ⅛th inch on each side would prove quite as strong per square inch as before.

Mr. James Nasmyth said he had tried a careful experiment on that very point; he cast some bars 2¼ inches square, and planed some of them down on each side to 2 inches square, and he found that these were 10 per cent. weaker for the proportionate transverse breaking strength. These bars were green sand castings, and consequently partially chilled; loam castings would not probably show the same effect; he considered the effect of chilling was to increase the strength.

Mr. Slate said he had made a somewhat similar trial, though not so careful an experiment, and he did not perceive any difference in the strength of the skin.

Mr. May observed, that ⅛th inch on every side might be too much to remove for ascertaining the relative strength of the skin alone, as the interior of a large bar was not so strong. It had been ascertained by the experiments of the Government Commissioners, that a cast-iron bar three inches square was only ⅔rds the proportionate strength of a bar one inch square, as the centre of the bar became less solid in cooling; consequently, a bar one inch square, cut out of the centre of a three inch bar, would be considerably weaker than a bar cast one inch square, and not from the circumstance of the skin being removed, but from the iron being less solid; if only about $\frac{1}{16}$th inch were planed off a bar, it would remove the skin, but he thought the strength would be found not to be injured.

Mr. J. Nasmyth considered the skin effect extended more than ⅛th inch deep, at least the chilling was perceptible so far.

Mr. G. England remarked, that if the less dense part of a solid axle at the centre were taken out by boring, the axle would not be proportionately diminished in strength; and this was in effect done in the hollow axle, with the additional advantage of the internal pressure, making the iron as sound throughout as in a thin bar, and considerably sounder and stronger than it could be in a large bar or shaft.

The Chairman said it was certainly much easier to make a bar 1 inch thick, of good quality and fibrous throughout, than one 3 or 3½ inches thick; and in effect the hollow axle was a bar less than an inch thick throughout, in place of the ordinary solid axle, 3½ or 4 inches thick.

Mr. McConnell thought it had to be defined what was meant by the term skin; in forging any bar it became denser gradually at the surface, and consequently stronger, the effect penetrating to a greater or less depth, according to the circumstances, and it was that he referred to, not a mere film on the surface.

Mr. Slate remarked, that in reference to the crystallisation produced in iron by concussion, he thought the effect did not take place unless the strain was beyond the elastic limit more than five or six tons per inch, so as to cause a permanent change in the arrangement of the particles of the iron. He had tried an experi-

ment in connection with Mr. Wild, in which a weight was suspended by a bar an inch square, and was lifted up and down eighty times per minute by an eccentric worked by a steam engine, constantly, night and day; this was continued for a length of time that was supposed equivalent to the effect of twenty-five years' work, but no change or crystallisation in the iron was perceived.

Mr. McConnell observed, that whatever was the nature of the strain, and the change produced by concussion, the effect of the continued blows and concussion to which a railway axle was subjected, must be greatly diminished when the axle had a large hollow through the centre, instead of being entirely solid, as the effect of a blow on one side would be mostly lost in the vacant space of the centre, instead of being all communicated through the mass of the axle. He showed specimens of a hollow and a solid axle, which had been run hot for two hours without oil in a lathe, at a speed corresponding to about 20 miles an hour travelling: the solid journal broke off with 179 blows quite short and crystalline, but the hollow journal would not break transversely, and split longitudinally in several places with 400 blows, and did not appear injured.

Mr. Adams said he thought the conical journals were preferable to the ordinary cylindrical ones, and they were particularly adapted to the manufacture of the hollow axles, by avoiding the sudden shoulder. He had found the conical journals less liable to heat than the others when well fitted; in the cylindrical journals, as square shoulders were found preferable in practice to shoulders much rounded, it was important to maintain a uniform strength of metal at the shoulder.

The Chairman observed, that the subject of railway axles was of great importance for safety and economical working, and the new hollow axle appeared to be a valuable and successful improvement. He proposed a vote of thanks to Mr. McConnell for his communication, which was passed.

The following Paper, by Mr. R. S. Norris, of Warrington, was then read :—

IMPROVED RAILWAY JOINT CHAIR.

In bringing before the Institution a plan for a new kind of Joint Chair for Railways, it will be unnecessary to expatiate on the advantages of a *firm joint*, as regards economy of maintenance of the road and rolling stock, and safety.

The object of this Paper is to describe a method which has been in use on a crowded part of the London and North-Western Railway for above eighteen months, during which time it has stood well, and is now being extensively used on the same line.

The plan is to cast a chair or coupling on the rails at the joints as they lie in the line, by means of chills and a portable cupola. The hot metal flowing freely into the chill is allowed to come in close contact with the rails, and in cooling contracts so as to grip the ends of the rails firmly together. The great object to be attained is the converting of the rail into a continuous girder, which shall not deflect at the joint more than at any other part; every successive year's experience having forced the attention of engineers and others to this point, to attain which many plans have been tried with more or less success.

Whatever mode of joint is adopted, or whatever method of joining the ends of rails, it is necessary that a certain allowance should be made for the longitudinal motion caused by the expansion and contraction of the rail. This object is attained, wherever necessary, by putting the chills, previously heated, on the ends of the rails for a short time, until they become hot, when they are taken off and a thin wash of loam and blacking is laid upon the rail end, which instantly dries on, and when the melted iron is poured against it absolute contact with the rail is prevented. Although provision is thus made for the expansive and contractile force of the rail, the cavity in the Chair being parallel to the rail, clips it sufficiently tight to prevent any vertical or lateral motion of the rails; the amount of surface of contact between the rail and chair is about 100 square inches, being 50 square inches to each rail end.

This great surface prevents any perceptible wear taking place on the rail ends from the longitudinal motion of expansion; and as no motion can take place vertically or laterally, no shock can take place by the action of the wheels, so that the joint will remain good for years, which has been confirmed by practice, so far as it has gone.

The operation of casting is very simple, and is performed without hindering the passing of trains during the execution of the work.

The apparatus consists of chills and a portable cupola, and the process is as follows, when operating on a line already laid :—Each joint sleeper or block is first lowered by the platelayers about three inches, so as to give room for the application of the chills, or is removed altogether for the time, and the old chair being taken off the joint, the chills are applied, shown in side elevation in Fig. 10, Plate 21, in Plan, Fig. 2, and in Section, Fig. 3, consisting of a bed-plate A, with two lips, one on each side, holding down the side chills B and C, which slide in the grooves; these are put to the rail and held together by the screw clips E E, forming a mould for casting the chair. This operation is quickly performed, and the chill is then packed under temporarily with loose metal plates; the moment this is done a train may pass over it without hindrance.

The two steel pins D D are then put in their places in the chills, and form, when in their places, the cores for the holes of the holding down spikes. The chill mould being thus fastened in its place, is ready for the melted metal, which is run into it at the lip F, until it is level with the top of the sides at G, which is a large open space as shown on the Plan, Fig. 2, at G, and by allowing such an ample space for the escape of air, this prevents all possibility of blowing.

The chills are made to fit the rails by a projection at each end. H H, which grips the rail firmly, and a little loam is applied on the outside, to prevent the hot metal making its way out of the chill mould.

After a lapse of about five minutes the mould is taken off, which is done in an instant, leaving the Chair as shown in Fig. 4, and

end elevation, Fig. 5. The form of this Chair is such as to make it a strong and rigid clip, closely fitting the two ends of the rail along its whole length. Chairs may by this method be cast of any form. When the Chair is cold enough, the sleeper or block is replaced, and the Chair spiked to it.

The operation is the same in relaying new roads, only that the expense of lowering or removing the block or sleeper is saved.

The metal used up to the present time has consisted of old chairs, mixed with a little new iron. This is melted in a portable cupola, shown in elevation, Fig. 8, Plate 22, and plan, Fig. 9; it is formed of a cylinder A A, of sheet iron 1-16th of an inch thick, 2 feet 3 inches in diameter, and 4 feet 6 inches high, lined with fire bricks and clay B B, in the usual manner, 4 inches thick.

The cupola weighs about 6 cwt., and is easily lifted by the workmen on to a platelayer's lorry, and taken to the place required, when it is lifted off and placed on a few sleepers laid on the slope of a cutting or embankment. When once so placed it will serve for half a mile of road without moving again, as the metal is so hot as to enable its being taken in a moulder's ladle on a lorry to the chills at a quarter of a mile on each side the cupola

The cupola has a belt or air chamber at C C, into which passes the air from the fan, and it has four tuyeres of two inches orifice to admit the air to the fire. The fan D consists of a chamber 1 foot 10 inches inside diameter, and 9 inches wide, and weighs about 3 cwt.; it is detached from the cupola by drawing out the nozzle from the entrance to the air belt, and can then be lifted separately into its place. The fan is either turned by hand winches E E, or when the operations are extensive, by a small steam engine, Figs. 10 and 11, weighing about 10 cwt., and can be lifted by eight men, and placed on and off a lorry and on to the slope, in the same manner as the cupola.

The yield of metal from so small a cupola is very great: as much as 3½ tons has been run down in seven hours by two men turning the handles of the fan, and nearly 4½ tons by the use of the engine in the same time.

A smaller cupola, weighing about 2 cwt., is used for repairs of the line.

A good fastening is made for middle chairs by taking out the wooden key from the common middle chair, and casting an iron one in its place, as shown in Fig. 6. This is done by heaping dry sand round the Chair, as it stands in its place at I I, and then running metal into the cavity so formed, coloured red in the drawing, leaving a lip projecting over the Chair at K K; only a few of these have yet been put down, but they have stood the test of two years' working over without failure, and are still tight. In casting, the hot metal running into the Chair expands it, and its contracting upon the cast key in cooling makes it tight.

It may be remarked, that the new Chair occupies exactly the same position on the sleepers, and has the same fixing as the common Joint Chair, so that in case of damage to the line from accident or slips, it can be repaired quickly in the ordinary manner, by using the old Chairs and wood keys until the small cupola can be brought to bear.

Mr. Norris exhibited specimens of the Chairs and the cast-iron Mould, complete; also a specimen of one of the new Joint Chairs from the North Union Railway, which had been laid down for eighteen months in a line of great traffic, where 500,000 wheels had passed over it during the time; the two rail ends were cut off, and remained fixed fast in the chair, and the surface of the joint was level and smooth, although the rail ends had been much indented at the time the chair was cast on, from the rails having been recently turned.

The Chairman inquired what length of line had been tried with the new chairs, and how long they had been at work?

Mr. Norris replied, that five miles had been recently laid with these chairs near Rugby, and about a mile was previously laid near Crewe, and elsewhere, which had mostly been at work one and a half years.

Mr. Woodhouse said the recent trial of the chairs near Rugby had been made under his superintendence, and he had found the

result highly satisfactory. It had been intended to relay that portion of the line during the present summer, but the new Joint Chairs had proved of such benefit, that they would probably give several years additional life to that road. He consequently recommended the adoption of the plan on a considerable length at other parts of the line, which was now in progress.

The CHAIRMAN asked what difference was felt in the trains running over the joints on the portion that had been altered at Rugby?

Mr. WOODHOUSE said the joints could not be felt at all with the new chairs; there was no comparison of the ease in travelling over the old plan of joints.

The CHAIRMAN asked what was the usual time required for the process of casting the chairs?

Mr. WOODHOUSE replied that the average of the work done at Rugby was about one chair cast every four minutes, including the whole process of preparation.

Mr. SLATE remarked it was certainly a very ingenious process of casting the chairs, and must make a thoroughly firm joint; he inquired what was the expense of casting?

Mr. NORRIS said that the labour of casting cost about sixpence per chair, and the cost was about a shilling per chair, including all expenses except the metal, which weighed about 50lbs. The expense of casting was much diminished as the men got more experienced in managing it. At first they could only cast 40 chairs per day, but the rapidity of casting increased with practice to 80 per day, and now 120 per day were cast by common platelayers, who had never before had anything to do with melted iron.

Mr. SLATE said he had seen the first of these chairs 1½ years since, and had then an unfavourable opinion of their standing in work, from the great contraction of the melted metal in cooling on the rigid rail; but it appeared that the wrought-iron rail was expanded by the heat of the melted metal sufficiently to make the chair safe by its contraction again in cooling. He thought the new chair made a very perfect coupling of the rail ends, and was a great improvement on fishings and other plans, which he could only regard as make-shifts; and though they had a very good effect compared with the previous

plan of having nothing to couple the rails together at the joints, they were still far removed from perfection. The new chair might be said to be quite perfect, if it could be made quite fast on the rail without allowing it to slide.

Mr. NORRIS observed that only every third or fourth joint was made a slip-joint for expansion; he was aware what a great advantage it would be to have no slip-joints, and by no means maintained that to be impracticable; the expansion of the rails successively by the heat of casting the chairs on, would perhaps elongate them sufficiently to make provision for the expansion from the highest temperature they would be afterwards exposed to, and the tension would then resist the contraction from cold.

Mr. MAY remarked, that Mr. Brunel had now many miles length of Barlow's rail on the South Wales Railway, all riveted fast together, without any provision for expansion, and no difficulty was experienced in consequence. There was some misconception on this point, respecting the action of expansion; it was limited in amount of force, and if opposed by a greater force no amount of expansion or contraction could take place. Wrought-iron raised in temperature 15° was expanded $\frac{1}{10000}$th of its length, and exerted a force of one ton per square inch of section by the expansion; consequently, no expansion of the rails would take place if a resistance were opposed of one ton per square inch for each 15° rise of temperature. He thought it probable, that Mr. Norris's plan ultimately would require to have no expansion joints to perfect it, and in many cases he did not doubt the plan being an excellent one.

Mr. JAMES NASMYTH said he had witnessed the whole process of casting the chairs, and fitting on the iron moulds, and considered it a very successful plan, and of the utmost value and importance to the durability of the line as well as to the safety of the public. The trains ran full speed over the red-hot chairs directly after they were cast. He thought the slight tortuosities of all roads, even in the straight parts, would be probably found sufficient to allow for the effect of expansion, without making any provision of slip joints.

Mr. MAY suggested that an experiment could readily be tried to ascertain the actual amount of expansion of the rails, by having a number of thin graduated wedges, to be dropped into the joints at

the hottest part of the day and at night, to measure the amount of expansion over a considerable length of rail. It would probably be found to be very insignificant, as the ordinary chairs offer a considerable resistance to a longitudinal motion of the rail, by the hold of the keys on the rail, the chairs on the keys, and the ground on the sleepers; though of course the resistance in Barlow's rail was a different case, where the rail, chair, and sleeper were all one.

Mr. Woodhouse remarked, that in laying the rails the men place small wooden or iron packing pieces 1-16th of an inch thick between the rail ends at the joints, to make the ordinary allowance for expansion, and they always find that if these pieces are put in early in the day they become so tight in the middle of the day that they cannot be got out, but are quite loose in the cool of the evening.

The Chairman observed, there was no doubt the expansive action of the heat would always produce its full effect, either by compressing the iron of the rails, or producing some motion or distortion in their position.

Mr. Norris said that cases had occurred of the road becoming hog-backed, rising with the sleepers out of the ballast, from the want of sufficient allowance for expansion, also in curves the rails and sleepers had been pushed bodily outwards in the ballast by the effect of expansion. The extreme change of length in this country, from 80° or 90° variations of temperature, amounted to a yard per mile, and this yard length must be disposed of somewhere in each mile, either by sliding or tension, or else by bending upwards or laterally, if there was not less resistance to compression of the iron.

Mr. C. Cowper remarked, that the extreme change of temperature of 90° would cause a total strain on the iron of 6 tons per square inch, at 1 ton for 15°, which amounted to the very severe total force of 40 or 50 tons on the whole sectional area of the rail of 7 or 8 square inches, to overcome any supposed resistance.

Mr. May thought the change of temperature in the rails would be considerably less than that of the air, because they were partly buried in the ground, and must therefore follow the temperature of the surface of the earth, which fluctuated much less than that of the air.

Mr. Duclos remarked, that the expansion or contraction of the rails would only take place from the mean temperature to the maximum or minimum, and as the mean temperature of the air in this country was about 50°, and the maximum 90°, making a change in the air of 40°, the actual change in the rails from the mean temperature was probably less than 30°, causing a strain of not more than 2 tons per inch expansion or contraction.

The Chairman observed, it was an important subject for consideration, whether the allowance for expansion could be entirely dispensed with; and the new Chair appeared an important step in that direction, and might lead to doing away with longitudinal bearings.

Mr. Norris said that his attention had been first directed to the subject of this Chair about two years since, by the circumstance of a very extensive alteration having been in contemplation from the ordinary rail and cross sleepers to a bridge rail on longitudinal timbers, the alteration being proposed entirely on the ground of obtaining a superior coupling of the joints with the longitudinal bearing, than the ordinary rail and chair. But he objected to the bridge rail and longitudinal timbers as more expensive: and the idea then occurred to him of running the melted metal into the chairs to fill them up solid, and make a rigid coupling of the joint; and this led him to casting the joint chairs solid upon the rails in their places, as the complete way of carrying out the object.

Mr. Woodhouse remarked that the process of casting the Chairs would be going on for some time near Weedon and Leighton, on the London and North-Western Railway, and he should be glad to show it to any Member who might wish to see the process.

A vote of thanks was then passed to Mr. Norris for his Paper.

The meeting then adjourned.

PROCEEDINGS.

OCTOBER 26, 1853.

The GENERAL MEETING of the Members was held at the house of the Institution, Newhall Street, Birmingham, on Wednesday, October 26th, 1853; CHARLES BEYER, Esq., Vice-President, in the Chair.

The Minutes of the last General Meeting were read and confirmed.

The following Members were put in nomination for the election of Council and Officers of the Institution at the next Annual Meeting, when the President, Vice-Presidents, and five of the Council in rotation would go out of office, according to the rules of the Institution.

PRESIDENT.

WILLIAM FAIRBAIRN, .	Manchester.

VICE-PRESIDENTS.

(Six of the number to be elected.)

SAMUEL H. BLACKWELL,	Dudley.
WILLIAM BUCKLE, .	London.
EDWARD JONES, . .	Liverpool.
RICHARD PEACOCK, . .	Manchester.
*JOHN PENN, . . .	London.
JOHN RAMSBOTTOM, . .	Manchester.
*ARCHIBALD SLATE, . .	Dudley.
ROBERT STEPHENSON, M.P.,	London.
*JOSEPH WHITWORTH, .	Manchester.

COUNCIL.

(Five of the number to be elected.)

*CHARLES BEYER, . .	Manchester.
*WILLIAM BUCKLE, . .	London.
JAMES FENTON, . .	Leeds.
BENJAMIN GOODFELLOW, .	Hyde.
*EDWARD HUMPHRYS, .	London.
*EDWARD JONES, . .	Liverpool.
JAMES KENNEDY, . .	Liverpool.
SAMPSON LLOYD, . .	Wednesbury.
*JAMES E. MCCONNELL, .	Wolverton.
WILLIAM MATHEWS, .	Birmingham.
*WILLIAM A. MATTHEWS, .	Sheffield.
EDWARD SLAUGHTER, .	Bristol.

TREASURER.

*CHARLES GEACH, M.P., .	Birmingham.

SECRETARY.

*WILLIAM P. MARSHALL, .	Birmingham.

*(The Officers for the present year are marked thus *.)*

The following paper, by Mr. William S. Garland, of Soho, Birmingham, was then read :—

DESCRIPTION OF THE NEW PUMPING ENGINES AT THE BIRMINGHAM WATER WORKS.

The subject of the present paper is a description of a pair of pumping engines, manufactured by Messrs. James Watt and Co., of Soho, for the Birmingham Water Works Company; and the intention of the author has been more to place before this Institution a record of well and successfully executed works, rather than to claim any particular novelty in their construction.

These Water Works were established in the year 1830, and the Company then erected two engines, having cylinders of 61 inches diameter, and 8 feet stroke, each working two pumps of 18 inches and 20 inches diameter, and of 6 feet and 8 feet stroke respectively to the lower levels of the town, or working one pump only when raising water to the upper reservoir. These engines were found of sufficient power for the necessary supply until the year 1850, at which time the demand had so much increased that the Company determined, at the recommendation of Mr. Rofe, their engineer, to augment their establishment by the addition of two new engines of greater power than the old ones.

The cylinders of these engines are of 72 inches diameter and 10 feet stroke, working a pump of 23 inches diameter, also of 10 feet stroke, under a head of 252 feet, which with the bends in the main and friction is equal to a total resistance of 285 feet, and to a load upon the plunger of 124 lbs. per square inch, or upon the steam piston of 13 lbs. per square inch. The weight upon the plunger required to overcome the load upon the air pump, the friction of the engine, and to maintain a velocity of 10 strokes per minute, is nearly 26½ tons, which is equal to 142 lbs. per square inch upon the area of the 23 inch plunger, and 14½ lbs. upon the piston; the power therefore of each engine when making 10 strokes per minute is equal to 180 horses; and the total power which the Company now have for supplying the borough is equal to 530 horses.

Fig. 1, Plate 23, shows a general elevation of one of the engines, and Fig. 2, Plate 24, is a plan showing both the engines. The cylin-

ders AA have steam cases, and are enclosed in a covering of felt, having an outside casing of wood, BB, (as shown upon a larger scale in Fig. 3, Plate 25,) to prevent the radiation of heat, and the top of the cylinder and upper nozzle are covered in a similar manner.

Fig. 3 shows a vertical section of the cylinder, with its piston and rod, and side section of the nozzles. Fig. 4 is a front section of the nozzles, showing the steam-valve C, equilibrium-valve D, and exhaustion-valve E. These valves (shown to a larger scale in Fig. 5, are 13, 15, and 18 inches diameter respectively, and of the double-beat construction, by which the principal part of the pressure that the common conical valve is subject to is removed. The steam governor valve F is made of the single conical form, (there being no necessity for making this valve upon the double-beat principle,) and it is regulated by a screw and wheel handle.

The load upon these engines is a variable one, to the extent of the difference of the dead level of the upper reservoir and the amount of friction of the water *in transitu*, and it sometimes happens that the water is being drawn off faster than the engine supplies it, and the velocity of the water beyond where the great draught occurs is consequently decreased, and the resistance proportionably diminished.

To prevent any accident to the engine by going out too suddenly, in consequence of this diminished resistance, a throttle-valve G is placed between the upper and lower nozzle, and in the pipe communicating with the top and bottom of the cylinder, which is regulated in its opening by a screw and wheel handle in a similar manner to the steam governor or throttle-valve, and by thus contracting the passage, or in other words, wire-drawing the equilibrium, the equalization of pressure between the top and bottom of the cylinder is more slowly formed, during the time the plunger is descending, to the extent the weight is in excess of the diminished resistance. In these engines this valve has been found of invaluable service, and it will even hold the plunger at the top of the stroke. It acts exactly like putting on a break to a crane when lowering a weight, without absorbing any power or causing any disturbance to the working of the engines. The piston is represented in Fig. 3 as descending, or what is technically called making its in-door stroke, and the steam and exhaustion-valves are open, and the equilibrium-valve closed.

In Fig. 4 the steam governor valve F and the equilibrium governor valve G are represented as wide open.

The opening of the steam, injection, and exhaustion-valves is regulated by a cataract, and the speed of the engine is thus under the control of the engine-man. The equilibrium-valve is opened by quadrant catches, and is dependent upon the closing of the exhaustion-valve, the former being opened upon the closing of the latter, and is shut in the usual manner by a tappet upon the plug-rod.

The injection-valve is also made upon the double-beat principle, to render the strain upon the exhaustion-valve spindle as little as possible, by relieving it of all unnecessary pressure, the underside of it being open to the condenser.

In the event of the bursting of any pipe in the main, and the resistance to the plunger being suddenly removed, a detent is fixed upon the plug-rod, to prevent the repetition of a blow upon the spring beams by the catch pins. This detent comes into action upon the engine making more than its usual length of working stroke, by holding the steam-handle down, and thus preventing the opening of the steam valve. This adjunct to the hand gear, though it may never be brought into operation from such an occurrence, would evidently be of great value in such a case.

In Figs. 1 and 2 is shown the air-pump H and condenser I; the former is of 34 inches diameter and 5 feet stroke, and the latter is of similar capacity. The air-pump bucket is fitted with a brass annular or ring valve, and the delivery and foot valves are of the usual construction, or what are termed flap valves. A vacuum is obtained varying from 27 to 29 inches, according to the state of the atmosphere.

Each engine has its separate condenser cistern, formed of cast-iron, which is supplied by a cold-water pump of 13½ inches diameter and making 5 feet stroke.

The feed-pump W is of 6½ inches diameter, and 2 feet 6 inches stroke, fitted with an air-vessel, shown in Figs. 1 and 2.

The main pump, with its suction and delivery pipes and air vessel, is shown in Figs. 1 and 2, and a section to a larger scale is given in Fig. 7, Plate 26. The plunger K, as before stated, is 23 inches diameter, and of the same length of stroke as the steam piston, viz., 10

feet. The suction-valves LL, and delivery-valves MM, (shown enlarged in Fig. 6,) are of the double-beat kind, and fitted in pairs for the purpose of giving additional security to the action of the pump in the event of one of them sticking or becoming otherwise deranged. They are of cast-iron, and their beating faces are composed of a mixture of tin and lead, which is run into a dovetail recess turned in the cast-iron seat, and thereby becomes perfectly fixed. The water-way through these valves is of the same area as the plunger, and the lift of them is about 2 inches, the blow when shutting being scarcely perceptible. These valves were taken out after 6 months' work, and the beating faces of them were found to be as perfect as when they were first put in.

The air vessel N is 7 feet internal diameter and 18 feet high, or 15 feet high above the delivery branch into the main, and it is replenished with air by a separate pump O, of 6 inches diameter and 3 feet 6 inches stroke, shown in Figs. 1, 2, and 7. An air-cock P is fixed upon the suction pipe of this pump, by which the necessary quantity of air to be supplied is regulated. This cock only requires to be partially open, and when closed entirely, the pump lifts water only.

The air-vessel is of great importance, as by its equalizing action the motion of water in the mains is rendered continuous, and a less weight in consequence is required to give the necessary velocity to the descent of the plunger in the out-door stroke. At the top of the pump-plunger is fixed the pole case, containing the necessary weights to overcome the load or resistance, and, as before stated, is equal with the plunger and rod to about 26½ tons.

Upon the first delivery pipe joining the air-vessel is fixed a safety discharge-valve Q, Fig. 2, of 6 inches diameter, loaded by a lever and weight a little above the pressure upon the main, to prevent any undue force being thrown upon the pump from the accidental shutting of the sluice cocks between the engines and the town.

The main lever or working-beam RR, Fig. 1, is 30 feet long, cast in 2 plates, each of 3 inches in thickness, and the depth of it in the middle is 6 feet, and at the ends 2½ feet. Each of the plummer blocks has saddles of cast-iron between them and the wooden spring beams SS, which latter are 30 inches deep and 20 inches wide, of the best

Memel timber, and formed of 6 pieces in section, bolted and bound together with wrought-iron straps. These beams are carried by the lever wall T, and by the end walls of the house.

The catch-pins UU are of wrought-iron. The parallel motions VV are of the usual kind, which require no further explanation than what is shown in the drawing of the general elevation of the engines.

It may be interesting to state, that the quantity of water lifted by every stroke of each engine is equal to 180 gallons, or 1800 gallons per minute, and 108,000 gallons per hour, weighing upwards of 483 tons lifted in each hour.

Mr. Garland explained the drawings of the engine and pump, and stated that the first engine was started in July, 1852, and the 2nd in April, 1853.

Mr. Cowper inquired whether it had been found requisite to have double valves to the pumps from any accidents having happened, as there would be the disadvantage of an additional load on the piston to lift the extra valves, which would probably amount to 1 lb. per square inch? He thought the area of the valves was large and supposed the object was to diminish the height of their lift.

Mr. Garland said no difficulty had been experienced with the valves; the double valves were only adopted as a measure of precaution, for obtaining additional security to the action of the pump working under such a heavy pressure.

Mr. Ramsbottom asked what pressure of steam was employed, and whether it was worked expansively?

Mr. Garland said that the pressure of steam was 12 lbs. per square inch, and it was cut off at ⅓rd of the stroke, expanding through ⅔rds.

Mr. Ramsbottom observed, that as there was a constant weight on the plunger to force the water, and the steam was employed only to lift that weight, there appeared no provision for variation in the resistance to be overcome.

Mr. Garland replied, that the load on the engine was constant, except the variation in friction of the water in the mains, according to the level at which the greatest discharge of water happened to be tak-

ing place, the water being always forced against the head of the upper reservoir at the highest part of the town, which was 252 feet above the engine. The only difference made would be in the speed of the engine; the usual speed was 10 strokes per minute, equal to 200 feet per minute average speed of the steam piston and the pump plunger. The actual pressure of water on the pump, 124 lbs. per square inch, as named in the paper, was measured by a Bourdon's gauge, fixed in the engine-house; and there was found to be very little fluctuation in the pressure, the variation rarely amounting to 5 lbs. per inch.

Mr. Ramsbottom inquired what duty had been obtained by the engines, from the coal consumed?

Mr. Garland said that the actual duty had not been ascertained, because the only fuel used was Staffordshire coal-slack; and as its evaporative value compared with the best Welch coal (which was invariably used in testing the duty of a pumping engine) was not known, there had been no opportunity of obtaining a definite result as to duty.

Mr. Cowper remarked, that the steam pressure was small as compared with the Cornish pumping engines, and he considered that a higher pressure would be more economical. He thought the pump appeared large for keeping the air-vessel supplied with air, and inquired whether it had been found necessary?

Mr. Garland said the pipes from this pump were found to get hot if sufficient water was not pumped with the air, from the quantity of heat liberated from the air under so great a compression, which was otherwise carried off by the water mixed with the air; and there was no objection in having the pump large, as the extra power for working it was spent usefully in pumping water.

Mr. Ramsbottom asked whether any experiments had been tried to ascertain the proportion of air absorbed by the water, as it was an opportunity from which some interesting results might be obtained?

Mr. Garland replied that the experiment had not been tried, but the quantity of air absorbed was certainly considerable in amount under that pressure.

The Chairman inquired about the construction and working of the pump-valves and valve-seats?

Mr. Garland said the valves were cast-iron, with faces and seats of a composition of tin and lead run into a dove-tailed groove, which was

found to be just the right degree of softness, and appeared to stand better than any other material.

Mr. Cowper thought that composition was certainly the best for the purpose; wood faces had been originally used by Harvey and West in their double-beat valves, but the valves were now much improved by using the tin and lead faces, which adjusted themselves accurately in work, and were very durable. He thought the form of valve shown in the drawings was originally due to Mr. Slate.

Mr. Garland said he believed that form of valve was originally designed by Mr. Slate.

Mr. Cowper remarked, that he thought it was preferable to make a pumping engine double-acting, on the bucket and plunger plan, with the plunger half the area of the bucket, so as to pump half the water in the up-stroke and half in the down-stroke, enabling an engine and pump of half the size to do the same work; also to add a crank and fly-wheel, and work at a higher speed, which further reduced the size and cost of engine and pump. In one instance that he knew, there were four 150 horse power engines on this plan working very satisfactorily, from 12½ to 21 strokes per minute, with 7 feet length of stroke. But he considered the horizontal engine with direct-acting pump and crank. was the most advantageous and economical when the water to be pumped was near the engine-house floor.

The Chairman observed that it was an important subject, and the paper read was of much interest, from its practical nature: it was important for the Institution to obtain such papers, as accurate descriptions of machinery that had been executed and worked successfully. He proposed a vote of thanks to Mr. Garland for his paper, which was passed.

The following paper, by Mr. Robert Waddell, of Liverpool, was then read:—

ON AN ESCAPE WATER-VALVE, AND A GOVERNOR FOR MARINE STEAM ENGINES.

The horizontal engine has of late years become a favourite engine in the British Navy, for the screw steam ships have the advantage of being better protected from shot than the vertical engine, as the horizontal engine can be placed in the ship entirely under the water line; the boilers are also kept as much under the water line as possible, for the same purpose. All boilers are liable to prime, more or less, but when they are confined in the height of steam room, they are more apt to do so, as in this case, and carry a considerable portion of water from the boilers into the cylinders along with the steam.

Water in the cylinders has, no doubt, been the cause of more accidents to engines than anything else, and many cases occur of the bottoms of cylinders being forced out, pistons broken, piston-rods bent, and side-levers broken,—all from the effects of water in the cylinder.

This can easily be accounted for, from the great power the one engine has over the other when water accumulates in the cylinder; the two engines being connected together in right angles, if a few inches of water has got into one cylinder, which will prevent the piston from getting to the end of its stroke, the opposite engine will be near half-stroke, at which point it gives out the greatest power, as the piston and crank are travelling near the same velocity, while the piston of the first engine, from the position of the crank, is nearly at a stand; then the power of the second engine, exerted to compress the water, will be in proportion to the difference of velocity of the two pistons, plus the momentum of the engine. The fly-wheel of the land engine acts on it in the same way when the engine is turning its centre.

Escape water valves have been applied on cylinders to take off the water, to prevent accidents taking place from the accumulation of water in them, but with little success. The fault of the ordi-

nary escape water-valve is its being loaded like a safety-valve, so that no water can leave the cylinder till the piston forces it out, and then the strain is very severe, from the small area that the water has to pass through, which causes the damage to the engine.

The object of the improved Escape-Valve, described in the present paper, is to draw the water off the cylinder throughout the stroke, and not allow it to accumulate, as with the ordinary escape-valves, till the piston strikes the water. The construction of the valve is shown in Plate 27. Fig. 1 is a horizontal cylinder, with an escape water-valve attached to each end, to the flange G, shown separately in Fig. 2. B is a small cylinder attached at G; F is a float inside the cylinder, a spindle passes through the float, and is attached to it. A and C are two conical valves nearly in equilibrium, attached to the spindle with nuts at top and bottom of the cylinder; the top valve A is made like a piston on the under side, so that when it leaves its seat it will prevent a great rush of steam from passing. It is also made slightly larger than the lower valve C, so that the pressure of steam will assist in raising the valves, and a small accumulation of water about the float will open the valves; that is, suppose the float, valves, and spindle weigh 50 lbs. for the largest size of engine, and the pressure of steam in the boilers not to exceed 15 lbs. per square inch, and the top valve to be 3 inches more area than the bottom; then there will be 3 times 15=45 lbs. excess of pressure on the upper valve, being within a few pounds of raising the valves, without any water about the float. The float should be made with sufficient buoyancy to raise the valves when there is no pressure of steam to assist.

It will be seen from the construction that when water enters the small cylinder from the steam cylinder, the float is buoyed up, opening the valves and allowing the water to escape through the bottom of the small cylinder. There is a hole in the spindle to carry off any water that might collect in the float.

The top valve is made larger than the bottom one to answer two purposes, namely, for the pressure of the steam to assist in raising them when a small quantity of water comes about the float; and, secondly, when a vacuum is formed in the cylinder the valves are

kept shut by the atmospheric pressure being greater on the top valve than the bottom one; this will be the case if a great quantity of water enters the steam cylinder, the valves will then be kept open running it off, until the exhaust takes place.

The drawings show an escape-valve suited to a 400-horse power engine, with 93-inch steam cylinder; the escape-valves will then be about 6 inches diameter, and the float about 13 inches; this will give the float sufficient buoyancy to rise and open the valves before it is entirely covered with water, besides the assistance of the differential steam pressure on the valves.

A Marine Engine Governor to check the admission of steam when the engine runs away from the water, leaving the wheels or screw, is much required. The ordinary governor has been tried for the purpose, but was found not to answer, as its action is too slow in shutting-off and letting-on steam; also the pitching and rolling of the ship in a heavy sea is very much against its action, and from these defects it has been abandoned.

The ordinary method that is adopted at present, when the engines are racing in a heavy sea, from the water leaving the wheels or the screw, is for the engineer either to close the throttle-valve to the required extent, to prevent the racing, or stand by the engines, with the throttle-valve handle in his hand, watching the motion of the engines, to shut off the steam when the engine runs off, and let it on when the wheels take hold of the water. In a voyage across the Atlantic this has often to be done for several days, night and day; because closing the throttle-valve, and allowing the engines to go all the time throttled, when the wheels are in the water as well as out, diminishes the speed of the ship to a great extent. When the wheels leave the water, the steam that passes into the cylinders is lost, as the engines have nothing to absorb their power, besides the liability to break down the engines if they are allowed to race to any extent.

The Governor described in the present paper can be used equally as well on land engines as on marine, where the work they are doing is not of a steady nature, such as driving a rolling-mill or a saw-mill, &c. When the saws leave the log, or the iron leaves

the rolls, the engine has nothing to absorb the power, and will run off before the ordinary governor will shut-off sufficient steam, its action being too slow for such sudden changes.

The proposed Governor is shown in Figs. 3 and 4, Plate 27, applied to the steam-pipe to act upon the ordinary throttle-valve, or a separate valve may be fitted for it. A A is the steam-pipe, and B the throttle-valve; C is a small cylinder fitted with a piston and rod, and bolted to the steam-pipe; the ends of the cylinder are connected to the steam-pipe by two pipes, one above and the other below the throttle-valve. When the engine runs away, in consequence of the diminished resistance of the water, from the wheels or screw being out of the water, the pressure of the steam is also diminished by being wire-drawn by the throttle-valve; consequently, on the upper side of the piston, we have the pressure the same as in the boilers, and on the under side the diminished pressure due to the sudden expansion of the steam, in flowing into the cylinders. The effect is to depress the piston C, and shut-off the steam from the engines, by partially closing the throttle-valve; but when the pressure becomes equal, or nearly so, on both sides, the piston is raised, and the valve opened by the spiral spring S. The stops H on the lower end of the piston-rod can be adjusted by set screws, to allow the throttle-valve to be opened and closed to the required amount.

It will be seen by examining the Governor, that when the throttle-valve is closed, it will remain so if time is not allowed for the space between the valve of the engine and the throttle-valve to get filled to the same pressure as above the valve, so that an equilibrium of pressure may take place on the piston, then the spring will open the valve; if the throttle-valve opens too soon, the stop H must be altered, to allow the throttle-valve to close further, so that the space between the throttle-valve and the engine-valve will take longer to fill, and the reverse if it opens too soon.

A working model of the escape water-valve was exhibited; and the Secretary explained that the author had been prevented from attending the meeting, having just started for America in the steamer of which he was the engineer.

The CHAIRMAN observed, that the governor appeared capable of more general application, and suitable for iron works as well as marine engines.

Mr. COWPER thought the governor might provent many accidents in iron works from carelessness of enginemen leaving their engines, by checking the increase of speed in the case of a sudden diminution of load on the engine.

Mr. BENJAMIN GIBBONS said that the common governor was found sufficient for this purpose, as power was absorbed by the very large mass of matter in motion in the heavy fly-wheels and gearing, which prevented any sudden change of velocity from taking place. The proposed governor would certainly act very sensitively, and was an ingenious and simple contrivance.

The CHAIRMAN observed that the water-valve would be an improvement on the ordinary escape-valve, from its constantly drawing off the water, and preventing any accumulation in the cylinder.

Mr. GIBBONS thought the escape water-valve a good plan for horizontal cylinders, such as marine screw engines, but it was not suitable for vertical cylinders, which were mostly in use.

Mr. CLIFT inquired what provision was usually made in vertical cylinders for the escape of the water?

Mr. GIBBONS said there was no provision made for its escape, except flowing through the ordinary steam-ports along with the steam, at the top and bottom of the cylinder.

Mr. RAMSBOTTOM said he had known much trouble to be caused with vertical cylinders by the accumulation of water, from the want of provision for carrying it off. The proposed escape-valve appeared likely to be advantageous in the case of horizontal cylinders, by preventing the accumulation of water; but in vertical cylinders it could only act fully at the lower end, as the water at the upper end could not be drained off except at the moment of the piston arriving at the top of its stroke.

Mr. COWPER thought there would be an objection to the application of the escape-valve, from air being drawn in a little at each stroke, because there must be some interval of time during the closing of the valve by descent of the float; and although assisted by an excess of pressure downwards, from the top valve being a little larger area than

the bottom one, the closing could not be instantaneous; and at every eduction stroke, air would be drawn in a little through the water at the bottom valve, as well as through the leakage of the upper valve.

The CHAIRMAN said they would be glad to have the results of practical trials of the governor and escape-valve; and proposed a vote of thanks to Mr. Waddell, which was passed.

The following paper, by Mr. John Ramsbottom, of Manchester, was then read:—

DESCRIPTION OF AN IMPROVED COKING CRANE FOR SUPPLYING LOCOMOTIVE ENGINES.

This Coking Crane was designed by the writer about two years ago, in consequence of the great wear and tear of coke skips used for coking engines, at the Manchester Station of the London and North-Western Railway, and the necessity that then more particularly existed fo coking the engines in the least possible time, owing to the limited space there was then for the traffic. The crane is shown in Plate 28, and consists essentially of a large wheel or circular rim 20 feet in diameter, made of iron segments A A A (see plan, Fig. 2) having arms B B B, 20 in number, which may be considered the jibs of so many small cranes. These are mounted upon one common post or pillar CC, which revolves upon bearings at top and bottom, and each arm or jib is tied by a rod DD, to a hollow cast-iron cone, which is fastened upon the top of the pillar, and is adjusted by means of a screw and nuts. In fact, the whole may be considered, so to speak, as twenty small cranes working from one common centre. Around the circumference of the rim are suspended, at equal distances, twenty wrought-iron cylindrical buckets, E E E, 2 feet 6 inches diameter, and 2 feet 8 inches deep. Each bucket is fitted with a bow handle and swivels, so as to be readily turned over when its load is to be discharged. The segments A A A are also provided with teeth upon the lower edge, which gear into a pinion G, and the movement is carried forward to the handle H by means of the two pairs of bevil wheels, and in such proportion as to give 115 revolutions of the handle for one of the crane. The chief peculiarity, however, consists in the main post being fixed in an inclined

position. This is done to such an extent as to throw one side of the rim 6 feet higher than the other, and it will be seen from the drawing that the buckets on one side are sufficiently low to be filled direct from the waggon L, and on the other sufficiently high to deliver their loads upon the tender M. The buckets hold in the aggregate 3 tons of coke, so that the crane will carry, ready for delivery at a moment's notice, sufficient coke to supply three passenger or two goods engines at least. Of course, when the crane is fully loaded, the whole is in equilibrium, and it can then be moved by a force sufficient to overcome the friction only; on the other hand, the greatest power is required when the buckets are empty on the descending side, and full on the other. The proportion given, however, will enable one man to work it under the worst circumstances.

In using this crane, the practice is to keep the buckets full as far as circumstances will allow, and any engine requiring coke has the tender backed under the higher edge of the crane; the cokeman then turns the crane round by the handle previously described, and continues to do so until the fireman or other person has turned over as many buckets of coke as are required. The time rarely exceeds two minutes for the delivery of 21 cwt. of coke, and is often less.

As respects the saving of labour, it may be mentioned that four men were formerly required to deliver coke at this station, and it is now delivered by two, and the skips are dispensed with.

The fact that this little machine has worked very satisfactorily during the last two years, has induced the writer to bring it before this meeting; it evidently possesses the advantage of carrying a considerable quantity of coke ready for immediate delivery, and of elevating, advancing, discharging, returning, and lowering the buckets by one simple movement.

There is one slight drawback, however, namely, that an engine cannot run past it, owing to the chimney; but where this is considered necessary, the crane may readily be fixed about 3 feet further from the rails, and the coke delivered by a moveable shoot.

The CHAIRMAN observed, that he had seen the coking crane described in the paper, and thought it a very simple and efficient plan; the one objection that had been named, of not leaving space for passing along the line by the side of the crane, might probably be remedied in several ways if required in another situation.

Mr. RAMSBOTTOM said that object had not been thought of at all in the present case, as it was at the termination of the line, where it could not be extended beyond the crane, and that was the only one on the plan at present tried. The crane had been found very convenient for use, as it required very little power to work it, and held a large store of coke always ready for loading the tenders; it had been in constant work for more than two years, with scarcely any expense for repairs.

Mr. COWPER thought the crane was well contrived for the purpose, and suggested that it might readily be made applicable to a situation where a clear passage was required on the line past the crane, by omitting a portion of the buckets on one side, perhaps one-third, which would always allow the passage of a train, when the blank side was turned towards the line; the same quantity of coke might be carried by increasing the size of the buckets or the diameter of the crane He thought that a perfect coking crane should, if possible, be balanced in all positions, for the engineman to be able to pull it round by hand, and take in a supply of coke without requiring a second man to help; on the same principle as the present large 8-inch water cranes, which supplied the water with great rapidity without help. This might be accomplished by working the crane round on a level instead of inclined, so as to be always balanced, and lifting the coke up previously to the level by other means.

Mr. WOODHOUSE thought there would be a difficulty in raising the coke by other means, and the oblique crane which he had frequently seen at work was a very convenient mode of gradually raising the coke by the same movement as changing the buckets. In some places the coke was raised up at once from the waggons to a high platform, and then loaded into the tenders by a shoot; but that plan was not so convenient for measuring the coke as the crane with buckets holding exactly 3 cwt. each.

Mr. RAMSBOTTOM observed that the average height the coke had to be lifted in loading the tenders was only 3 feet, as the coke was already

lifted an average of 3 feet, or half the total height 6 feet, in the process of filling the buckets all round.

Mr. Cowper suggested that each bucket when loaded on the platform might be slung up or raised by a small windlass, and then hooked on to the crane at the upper level.

Mr. Ramsbottom observed, it would certainly store up more power ready for coking the tenders, if all the coke were previously lifted up to the full height 6 feet, instead of an average of only half the height; but the simplicity of the machine would be somewhat interfered with.

Mr. Downing remarked that there might be room to pass the crane by fixing it a little farther from the line, and tipping the buckets over the side of the tender; there being no necesity he supposed to empty over the centre of the tender.

Mr. Lloyd suggested an octagon form for the purpose instead of a circle; he thought the same plan of crane would suit well for filling blast furnaces, where, as in Wales, there was not more than 6 feet to lift the materials in many cases.

Mr. Gibbons thought the plan might be very applicable in several parts of iron works, such as raising small coal and rubbish, and removing the cinder from the furnaces; he thought it a very good contrivance, involving the least possible expenditure of labour, where a large quantity of material was required to be lifted a small height.

A vote of thanks was passed to Mr. Ramsbottom for his paper.

The following paper, by Mr. Samuel Lloyd, jun., of Wednesbury, was then read :—

ON AN IMPROVED TURN TABLE.

In the construction of Turn Tables three leading principles have been followed; either the bearing has been on the centre only, with no bearings at the circumference, or with bearings at the circumference and none at the centre; or a combination of these two modes has been adopted by allowing the weight to rest in part upon the centre, and in part upon the bearings or rollers at the circumference; this last construction has been most frequently adopted. Most of the turn tables first laid down on railways were made to rest on fixed rollers, as Fig. 1, Plate 29, for the sake of economy; but although fixed roller turn tables are the cheapest kind in first cost, and were much used on the first railways made, live roller tables have been generally adopted latterly, from the greater ease with which they turn;—as in the fixed roller turn table the weight bears on the axle of the roller, producing rubbing friction, but in the live roller table it bears upon the circumference of the roller, producing only a rolling action without any rubbing friction, except in the guiding ring. Some fixed roller turn tables have however of late been constructed, with much larger rollers than those formerly used, which has the effect of perceptibly lessening the friction; but these tables seldom continue long in good working order, in consequence of the rollers *indenting* the top table. This is an objection to which all roller turn tables are subject, but those with fixed rollers most especially, from the top table always resting upon the rollers in these, in the same position, thus receiving the pressure always on the same points; and as the amount of surface in contact between them is very small, (see Fig, 2,) the whole amount of surface in contact between the surface of the rollers and the top table being not more than three square inches, as shown, if so much, the rollers soon wound the under surface of the top table, so that the latter becomes indented over every roller. As soon as this takes place, considerably more power has to be exerted to turn carriages upon them, as the resistance to be overcome is greatly increased by the whole weight having to be lifted out of each of the hollows formed from the above cause.

But in addition to the increase of friction occasioned by these indentations, they cause also great unsteadiness, making the table rock, and thus clatter and hammer against the rollers as each pair of wheels passes on and off its two opposite sides. This deteriorating action goes on to a greater or less extent in almost all roller tables, often occasioning the top to break, if it is not very strongly made; this rocking is often greatly increased, and occasionally entirely originates, from the centre pin being too tightly screwed down, so as to take the weight entirely off the rollers on one side of the table.

This defect has led to the construction of turn tables with a centre pin that acts merely as a centre guide, without taking any weight. Turn tables of this class, if made with radiating rollers, have the advantage of remaining very solid for a time after they are put in, but frequently this is not of long continuance, for all roller turn tables are unsteady, if the rollers are not *all* correctly turned to the same diameter, and cottered or screwed up exactly to the same distance from the centre; each roller being a portion of a cone, its outside diameter is greater than its inside, and if either of the rollers is screwed up too tightly, the table rides on it. This is sometimes occasioned after a few months' wear, by the pressure of the table top continually exerting a force tending to drive the rollers upon which it rests outwards, which is sure to be the effect if either of the nuts that screw them up becomes slack. This pressure tending to force the rollers off the roller-path, causes considerable friction against the guide ring at the boss of every roller, and is one cause of the heaviness with which even live roller turn tables work, causing railway labourers in goods stations, whenever they have the chance, to wrench them round by horse-power.

In an improved construction of roller turn tables extensively adopted, the weight of the table top is nearly counterbalanced by a weighted lever, which constantly tends to lift the centre pin without actually doing so, making the table much easier to turn, by diminishing proportionately the pressure on the rollers; the rollers also are not fixed as in common turn tables, but in an inclined position, as shown in Fig. 3, with their upper surfaces level, for the purpose of preventing the level of the table top from being disturbed by the surge of carriages passing over. In some turn tables the rollers have been made with rounded edges, as in Fig. 4, and level roller-paths, with the view of

lessening the friction of turning, and increasing the steadiness of the table by resting it on a plane instead of a cone; but these rollers have not been found to be durable, and the roller-path becomes worn hollow by them. A more successful plan for diminishing the friction has been the use of spherical balls instead of rollers, (shown in Fig. 5,) travelling round in a live ring, to prevent the balls from rolling off, but allowing them room to shift their position on the roller-path as they move round, which prevents them from wearing the roller-path into grooves; and as the balls travel in a circle, sometimes in one direction and sometimes in the contrary direction, they continually present a fresh portion of their surface for the bearing, which preserves them from being worn unequally.

There is one objection to these tables, but which applies still more strongly to roller turn tables, namely, the extreme difficulty of turning them in frosty weather, when the dirt on the rollers and roller-paths becomes frozen; horse-power is then often required to stir them, or a fire has to be lighted to thaw the congealed mud collected on them.

Centre bearing turn tables are practically free from this objection, and also from the one before referred to, namely, the bearing surface becoming indented, from the small extent of surface in contact with the rollers. A turn table of this class is shown in Figs. 6 and 7, Plate 89, of which many are in use. In these the whole weight is carried by the centre pivot or ball; any side pressure resulting from the weight to be turned not being balanced exactly upon the centre, being carried by the two sets of horizontal rollers A A that travel with the top table round the centre pillar B B, and are fixed to the jacket C C.

This description of turn table has two important advantages;—Great *ease in turning* and smoothness of motion, and great *durability*, numbers of them having continued in use for many years without requiring any repairs. The ease with which they turn is owing to the great leverage obtained by the power being applied at the circumference of the table, and to the resistance being confined to the centre ball and the rollers round the centre pillar, instead of being at the circumference as in roller tables, in which it acts at nearly as great a leverage as the power. So that while no leverage is obtained when the power is applied in turning a carriage at the outer edge of a roller table, a leverage of 14 to 1 is gained in a centre bearing turn table,

constructed as shown in Figs. 6 and 7, even if half the resistance be supposed to take place at the horizontal rollers, and only half at the centre pin.

Centre bearing turn tables as usually constructed have most of them two defects; namely, great extra cost of foundations, and unsteadiness and liability to deflect; the last being the most serious defect, which renders them objectionable for any situation where much traffic is likely to pass over them. Their deflection upon trains passing over them being caused by the whole of the weight of each carriage acting at a great leverage to strain the working parts of the table while running on and off. To meet this defect, a number of supplementary rollers have usually been fixed at the circumference, (see D D, Fig. 6,) for the purpose of catching the weight and preventing any undue deflection when the weight is passing on and off the edge of the table, these rollers being fixed a little below the level of the table top, so as not to touch the top and come into action until the top gives way by deflection, or by canting on one side. This plan has however the objection of being unmechanical, as it implies a certain degree of failure in the machine before it can come into full operation.

The *unsteadiness* of the centre bearing turn tables described above may be considered as the principal cause of their disuse, notwithstanding their superiority over roller tables in ease of turning; another cause being the expense and depth of the foundations requisite. The object of the present paper is to describe an improved plan of construction, that will remove these defects.

A Turn Table upon the improved plan is shown in Figs. 8 and 9, Plate 30; the action of which is as follows:—The centre pillar, A, is fixed on a block of stone or other suitable foundation, within which is fixed a toggle-joint or other lever, BB, which is connected with the centre pin C as shown: by means of this the turn table is raised when wanted for use, the lever then assuming the position shown by the dotted lines D D. The drawing shows the table not in use, the weight at such times being all carried on the outer ring EE, at the periphery of the table, and none upon the centre pin. By this means the table is made quite steady and solid, and not likely to be injured by trains passing over it; whereas, as soon as the centre pin or pivot is made to rise by means of the lever B assuming the position shown by the dot-

ted lines D D, which is worked into this position by means of a rod connecting it with another lever or toggle-joint F, forming one of the catches of the table, the turn table top is raised off the outer ring and may be turned with great facility, the weight then resting entirely on the centre pin or pivot BC.

Provision is made, as in other centre bearing tables, for the weight of the table not being equally poised on the centre, by horizontal rollers GG, which carry the side pressure, and serve by their contact with the centre pillar A to preserve the turn table in a level position while rising and while in use. When the turn table is no longer required it is again made solid by the handle M of the lever F, which forms one of the catches, being lowered into its original position.

Figs. 10 and 11 show another mode of construction, by which the same result is obtained of supporting the table top by its circumference when out of use, and upon its centre when in use. The action of the lever BB in this table is merely to raise the table sufficiently to disengage the blocks H H. When the table is not in use the lever is in the position shown at BB, but as soon as it is necessary to turn a carriage, the table top is eased off the four blocks H H at the circumference, under the main line rails, by being raised from $\frac{1}{4}$ to $\frac{3}{8}$ths of an inch by the action of the knuckle-joint lever F; by this time the stud I. which is fixed upon the long lever BB, having traversed to the end of the slot in which it works, carries the rod K with it, thus withdrawing the four blocks H H from under the outer ring E E. The long lever is now at the position shown in the drawing, or at the bottom of its stroke; the centre joint of the knuckle-joint lever F has now passed from one side of the centre line of the table to the other. The table top is exactly at the same level when the long lever is at the bottom of its throw as when it is at its top; the difference being that when the long lever is up as shown by the dotted lines DD, the table top is supported entirely at its circumference on the four blocks, which may be made of any convenient size; and while it is down the weight is on the centre pin C, when carriages may be turned with ease and rapidity. By means of the stud I traversing the slot in the rod K during the first part of the motion, the table top is eased off the bearing on the blocks H H, before the rod K is set in motion to withdraw the blocks; and by the same means, in lowering the table, time is allowed for the blocks

to be pushed home before the table top is lowered upon them, so that the blocks are relieved from the weight whilst they are being moved. Fig. 11 is a plan of this turn table, showing the position of the long lever BB, and the horizontal rollers GG, that work round the centre pillar A. At the end of the lever L a weight is fixed to balance the weight of the table top to within a few cwts.; the balance weight not being made heavy enough to raise the table top without the exertion of a slight pressure on the handle M. Other modifications of this improved table might be described, but as the principle in them all is the same, viz., to carry the weight upon the centre pin when the table is being used, and upon the circumference when not in use, it is not necessary in the present paper to do so.

This mode of construction insures a *solid turn table*, one very *easy to turn*, and a very *durable* one; the working parts do not get deteriorated by the passing of trains, and are so placed that dirt cannot collect upon them; the extent of bearing surface at the circumference is greatly increased and prevented from becoming indented as in roller tables; a smooth and easy motion is obtained by turning entirely upon the centre, as no inequality of bearing surface has to be overcome; also less oil is consumed for the centre bearing than for rollers, and the working parts are more easily oiled. In roller tables an increased load increases greatly the resistance to turning, and after some years' wear they work more heavily; but in centre bearing tables much less difference is experienced. Also, the cost of foundation, instead of being more, is rather less than that required for roller turn tables with a live ring and rollers, as a continuous ring of masonry is not required round the circumference, but only six or eight blocks of stone, one under each arm of the centre pillar, in addition to the centre stone, which is required in both descriptions of turn tables.

Mr. Woodhouse inquired whether any of the tables had been put down, and where they were at work?

Mr. Lloyd replied that none of the plan with the lever had been put to work yet, the first one was not yet ready for trial; but a considerable number (about 60) of the first plan, without the lever, were at work very satisfactorily, many of them on the Syston and Peterborough line. They answered very well for goods stations, but not for

the main line, because they deflected too much at the outer edge for trains to run over them; they were found to keep in order very well, and some of them had been 10 years at work.

Mr. GIBBONS thought there might be found a difficulty in getting the blocks to slide in always to their places under the table top, in the proposed lifting table.

Mr. LLOYD observed that there was only about 1 cwt. left unbalanced of the weight of the table top, so that there was very little work for the lever to do in lifting the top to the extent that was required for liberating the blocks, and pushing them into their places again. The whole weight of the top might be 3 tons for a 12 feet table, but it was nearly all balanced by the weighted lever, so that little more than the friction had to be overcome in lifting the top; the table was not lifted with a carriage on, as in previous plans of lifting tables, and was only to be lifted in the act of making it solid for the main line to let trains run over it, and in setting it free again, but was not lifted in the process of turning. The table top was only to be blocked for main line trains to run over, and was to be left free without supports at the circumference when turning and whilst carriages were pushed on and off the table for turning.

Mr. COWPER thought the height between the upper and lower rollers where they bore against the centre post was so small (making a great leverage at the circumference of the table), that a small play in the rollers would cause a considerable deflection at the edge of the table; so that it appeared liable soon to get out of level with carriages running on and off, if the top were not always blocked solid.

Mr. LLOYD replied that the rollers at top and bottom had the means of ready adjustment by screws, and no difficulty had been found in the tables at work, though they had no bearing at the circumference, while carriages and waggons were constantly being run on and off for turning. The only injurious deflection arose when trains of carriages passed over them; all those laid down were 12 feet diameter.

Mr. SAMPSON LLOYD observed that the centre post tables were found to have very little wear, and worked quite successfully; some of them had been in work 10 years without any bearing at the circumference; the

* An error in the position of the balance-weight in the drawing of Fig. 9, pointed out by some of the members, has been corrected in the engraving.

deep pillar engine tables had lasted very well for many years. The sliding blocks and lifting motion was a recent invention, for the object of making the table solid in the main line, when trains had to run over.

The CHAIRMAN remarked that in another plan of turn table, wedges were employed to make the top solid for the main line.

Mr. WOODHOUSE said that four wedges were pushed in by a lever, one under each line of rails, to give an additional bearing when the train passed over. He found the tables with live rollers answered much better than fixed rollers in goods warehouses and stations; the fixed roller tables worked very stiff.

Mr. LLOYD observed that the tables with a centre bearing only had an advantage in keeping all the working surfaces clean; the roller-path in ordinary tables was exposed to get dirty, increasing the resistance to turning.

The CHAIRMAN proposed a vote of thanks to Mr. Lloyd for his paper, which was passed; and expressed a wish for the results to be communicated of the practical working of the new turn table.

The following paper, by Mr. John Rolinson, of Brierley Hill, was then read :—

ON AN IMPROVED APPARATUS FOR PREVENTING EXPLOSIONS OF STEAM-BOILERS.

The object of this apparatus is to provide a self-acting means of closing the stop-valve, and opening the safety-valve, when a boiler is getting short of water, thereby cutting off all communication with the other boilers until the boiler is again properly supplied with water, and causing an alarm to call the attention of the engineman, before the water has got so low as to risk any injury of the boiler, preventing at the same time any increase of the pressure in the boiler from taking place.

Fig. 1, Plate 31, is a longitudinal section, and Fig. 2 a transverse section of the apparatus.

The float A falls when the water gets low in the boiler, and closes the stop-valve B, by the tappet C, and opens the safety-valve D, by the tappet E, causing an alarm by the rush of steam through the escape-pipe F, as soon as the water gets down to the level to which the apparatus is adjusted.

In a range of boilers working in connection, it sometimes occurs, from various accidental causes, that one of them becomes low in the water, causing danger of explosion, but with this apparatus such an accident is prevented ; and by closing the stop-valve and opening the escape-valve the boiler is cut off, and prevented from causing accident until properly filled with water again, when it resumes its former position, as the stop-valve then opens again and the escape-valve closes.

The pressure of steam is prevented from ever getting too high in the boiler, by the small cylinder G, with a piston one square inch area, which is open to the boiler on the underside, and is loaded on the top of the piston rod at H with as many pounds weight as the number of pounds pressure per square inch intended for the limit of the steam pressure. The piston lifts these weights in succession as the pressure rises, and at last lifts the lever of the escape-valve D ; a space is left between the different weights, so that the piston

to the top of the cylinder before it comes to the
the continual movement of the piston in the
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le K.
cked up in one cast-iron box, so that
e to increase the steam pressure, or to pre-
g of the alarm and the escape of the steam when-
ter level is suffered to get too low from any cause, or the
pressure gets too high. The apparatus is connected to the ordinary stop-valve fixed usually on boilers, and requiring only an alteration of the lever.

This apparatus has been at work for about two months, at Mr. Benjamin Gibbons', Corbyn's Hall, New Furnaces, near Dudley, and has proved quite satisfactory. It has been tried fully by blowing off the water from the boiler down to the level to which the apparatus was adjusted, when it was always found to act completely, and also when the pressure of the steam was raised too high.

Mr. Benjamin Gibbons said that the apparatus described in the paper was applied to one of a set of three boilers at his works, and proved quite satisfactory; it was found to act completely, either whenever the water was too low in the boiler, or the pressure of steam too high, and effectually prevented accident, and it appeared not liable to derangement.

Mr. Downing inquired whether there was the common safety-valve in addition, and what was the size of the escape-valve?

Mr. Rolinson replied, that an extra 5-inch valve was used, besides the ordinary safety-valve; the boiler that the apparatus had been applied to, was 6 feet diameter, and 30 feet long.

Mr. Downing thought the safety-valves were generally too small, and they would be better larger than 4 inches, by giving speedier relief to the boiler.

Mr. GIBBONS observed, that the size of safety-valves might be too much increased, as large valves would be more liable to stick fast; and he had never found the usual 4-inch valves not large enough.

Mr. RAMSBOTTOM remarked that a heavy float would be required to insure the action of the apparatus, and it would have to close the stop-valve against the pressure of steam in the boiler.

Mr. ROLINSON said the float was made large and heavy to insure certainty of action; but the steam from the other boilers would be always pressing on the top side of the stop-valve, and the pressure in the boiler on the under side of the valve was lowered by the steam being let off directly the apparatus acted.

The CHAIRMAN asked whether it was intended to apply a whistle to the escape steam-pipe, to make a more distinct signal?

Mr. ROLINSON replied that the steam was found to make sufficient noise in escaping without the use of a whistle, and there was the advantage of having no obstruction to its discharge.

Mr. GIBBONS remarked, that the whole apparatus might be locked up in a case of moderate size, about 3 feet high, including the float-chain and wheel, which would put it entirely out of the control of the men. He added that the whole cost of the apparatus was about £15 or £20.

The CHAIRMAN proposed a vote of thanks to Mr. Rolinson for his paper, which was passed.

The Meeting then terminated.

PROCEEDINGS.

DECEMBER 7, 1853.

The SPECIAL GENERAL MEETING of the Members was held in the Lecture Theatre of the Royal Institution, Mosley Street, Manchester, on Wednesday, December 7, 1853; WILLIAM FAIRBAIRN, Esq., Vice-President, in the Chair.

The SECRETARY read the Minutes of the last General Meeting, which were confirmed.

The CHAIRMAN congratulated the Members on the occasion of holding the first meeting of the Institution in Manchester, and expressed his confident expectation that a meeting in a district which had taken so prominent a part in mechanical discovery and improvement would prove advantageous to the Institution, and promote its objects by bringing forward many papers on mechanical subjects, and accessions of valuable members.

He invited the visitors who were present to join in the discussion, and remarked that the object was to have a full discussion of the mechanical merits of the several subjects presented to the meeting, without taking up any questions of priority or property of patent right.

The following Paper, by Mr. William Fairbairn, of Manchester, was then read:—

ON A NEW DESCRIPTION OF WINDING ENGINE.

The invention of the Steam Engine, and the rapidly-increasing demand for its assistance in almost every condition of civilized life, has produced, and is still producing, changes to which it would be difficult to prescribe a limit. It has a creative power in itself, and no sooner do we effect—through its aid—the most marvellous enterprises, than its powers and capabilities increase, and it becomes,

not the limit, but the harbinger of future and still greater events. Sixty years have scarcely rolled over our heads since its first introduction. Twenty years from that date witnessed the development of its powers in the draining of mines, the crushing of ores, and the spinning of the finest wool. Twenty years more, and we find it battling with the storm, and waging war with the elements against wind and tide. And, carrying forward the metaphor, for the next and last twenty years we again find it spreading its arms over the surface of many lands, and hurrying onwards the ponderous train with a celerity which not many years ago would have been, by the most sanguine, considered incomprehensible. Such is the short history of the progress of the Steam Engine; the whole of these wonderful changes having taken place within the limits of the writer's own recollection.

The subject of the following communication is a Steam Engine recently erected by W. Fairbairn and Sons, for F. D. P. Astley, Esq., of Dukinfield, for the purpose of winding coal from probably one of the deepest pits on record. It may be mentioned that this pit is, or will be in a few months—when the lower seam of coal is reached—upwards of 650 or nearly 700 yards in depth. It is sunk upon the dip of the strata, which descend at an angle of about 23° in the direction of north-east to south-west. The seam is what is called the Black Mine, and is justly considered the finest quality of coal in this country; and is believed equal to the best Wall's-end.

This pit from its great depth presents several peculiar features as respects its locality, with respect to surrounding mines. Being at the lowest level, it drains several of the adjacent pits, and thus has the onerous duty thrown upon it of draining the whole of the superincumbent works, or those at a higher level. On account of this circumstance, a large pumping engine, constructed by the above firm, has been erected for clearing those mines of water; this engine, from its efficiency and peculiar construction, may perhaps come under the notice of a future meeting.

The Winding Engine, which is shown in Plates 32 and 33, is constructed on the "direct-action" principle—the same in fact as those which some years since were constructed for Her Majesty's frigates, Vulture, Odin, and Dragon, by William Fairbairn and Co., at Mill-

wall, and in which the writer was ably assisted by his then partners, Mr. A. Murray, now the Government Engineer at Portsmouth, and Mr. Hetherington, of Manchester.

The pit from which the coal has to be extracted is 12 feet in diameter, and is walled with Ashlar stone to a depth of about 40 yards from the top, and from thence to a depth of 201 yards is a wedging curb of oak. From this point it is made water-tight through layers of sand and porous rock, by metal tubing, to a depth of 248 yards from the surface, and the remainder is walled with either stone or brick, excepting only in those parts where the sides are of solid rock, capable of standing without interior support.

The shaft is divided into three compartments, one being used for the pumps, and occupying about one fifth of the area of the shaft. Of these pumps there are five sets—four of them plunger pumps of 15 inches diameter, and varying in length from 400 to 420 feet each, and the fifth and lower set a 12-inch lifting pump; the engine working them is upon the marine principle, and worked expansively by high-pressure steam.

The other compartments or divisions form a large space for the slide bars and cradles, each of which admit of four coal boxes, one above another, and in this position they are raised at once from the bottom of the shaft to the surface. Each box has four wheels adapted to the tram-ways below and above, and as soon as they arrive at the top, or descend to the bottom, the loaded boxes are exchanged for empty ones above, and the process is reversed at the same instant below.

The engine is, to the best of the writer's knowledge, one of the largest and most powerful of the kind ever constructed for such a purpose. The cylinder, which is 60 inches diameter, and 8 feet stroke, stands upon a cast-iron pedestal, firmly bolted to a platform of masonry resting upon four cast-iron beams stretching across the house, with their ends inserted under the walls on both sides.

These walls vary from 4 to 3 feet in thickness as they ascend, and rise to a height of 50 feet above the foundations; and thus, it will be observed, from the weight resting upon the iron beams, a degree of solidity is given to the foundations which could not otherwise be obtained, unless at greatly-increased expense in the erection of an Ashlar platform.

From the foundations to the entablature which supports the crank shaft and two fly-wheels, and on the periphery of which the wire ropes wind, rise four massive cast-iron columns, equidistant on each side of the cylinder, and these being secured by bolts to the foundations below, and the entablature above, a complete connection is thus effected, which acting in combination with the weight of the engine-house walls, gives a degree of solidity more than sufficient to resist the reciprocating action of the engine at a pressure much greater than 30 lbs. on the square inch.

In this description of engine, where the action is direct from the piston rod to the crank, it usually occurs that the preponderating weight of the connecting rod, crank, and piston causes great irregularity of motion, and to remedy this defect, balance weights have frequently to be attached to the fly-wheel or some other part of the engine, to cause uniformity of motion. In the present engine these adjuncts are not required, as it has been contrived to balance the difference of weight in the up and down strokes by the lift of the air-pump, as may be seen by the drawings at A, B, and C, which show the fixed and oscillating levers. This answers the double purpose of exhausting the condenser and of forming radius bars for the direct vertical motion of the piston. In this operation a perfectly direct motion is not only effected, but the parts are so nearly balanced as to enable the engine-man to raise and lower any weight, however heavy or light, with an extraordinary exactitude; and in fact such was the accuracy of the motion, that the "sinkers" availed themselves of the engine for the purpose of lowering, raising, and setting the stones used in walling the sides of the pit.

The working of the engine is accomplished by eccentrics, from a shaft D, which extends from the crank to the opposite wall. These eccentrics give motion to the plug rod, which works the valves, and acting upon the lever or handle E, enables the engineer to regulate the speed and reverse the motion at pleasure. All these valves are double-beat, upon the equilibrium principle, as shown on a larger scale in Fig. 3, and the result is, that they are worked at any amount of pressure, without any increase of balance in the handling or the working of the engine.

For the purpose of winding or raising coal, flat wire ropes are now in general use, and those employed at this pit are of that

description. They each weigh about 2 tons, or 3 tons with the addition of the cradle and boxes. These boxes each contain 8 cwt. of coal, collectively 32 cwt., which is the load to be raised from the bottom of the pit to the surface in one minute. This gives a velocity of nearly 2000 feet per minute, or about 23 miles an hour, and taking the speed at and the height to which the load is raised, we have a power of nearly 220 horse, independent of friction, and the immense preponderance of rope which has to be overcome at starting from the bottom of the pit. This is to some extent equalized by the balance chain, which unrolls itself from the drum F in its ascent within the well behind, till the cradles meet, when the motion of the balance chain is reversed, and the chain begins to rewind upon the barrel as the descending rope begins to preponderate over the ascending rope.

Taking all these conditions into account, the engine will be found in regular working duty to be giving out a power varying from 400 to 450 horse-power.

The CHAIRMAN remarked that he had brought the paper before the meeting, simply as an account of an unusually large size of winding engine, the largest he believed that had ever been erected. The depth of the pit at present was very great, 500 yards, and when completed to the full depth would be 700 yards; a depth he believed considerably greater than any other pit he was acquainted with; the deepest was probably that at Bishop Wearmouth, which varied from 400 to 500 yards. This great depth, and the large quantity of coal to be raised, required the speed to be much greater than usual, and they had succeeded in safely working at a velocity equal to 23 miles an hour, in drawing up four boxes loaded with 1¼ tons. This was a point of great importance in the erection of the engine, as the supply of coal could not otherwise have been all raised by one shaft. The engine, which was direct-acting, occupied very small space in proportion to its power, and the large unbalanced weight on the down stroke of the steam cylinder was so effectually neutralised by the resistance of the up stroke of the air pump, that the engine could be managed with the greatest uniformity of motion required.

Mr. DYER inquired whether the same seam of coal was worked at a higher level at any other place?

Mr. FAIRBAIRN said the pit had been sunk at the lowest point of the portion to be worked for the sake of drainage, and the workings would be extended upwards from the pit; he was not aware how much higher the seam was elsewhere.

Mr. DYER observed that the rapid progress in the invention and application of the steam engine was very remarkable during the half century since its commencement by Watt, and was a great encouragement to further progress. The power of mind over matter seemed destined to proceed with an accelerating force; the last 25 years had done much more than the previous 25 years of the century.

He proposed a vote of thanks to the Chairman for the interesting and valuable communication he had brought before the meeting; and the vote was seconded and passed.

The following Paper, by Mr. Benjamin Fothergill, of Manchester, was then read:—

ON AN IMPROVED WATER METER.

Amongst the various objects to which men of mechanical genius have directed their attention for many years, that of producing a machine for accurately measuring the flow of water has been considered a great desideratum; and amongst the number which have been submitted to the public, that of Mr. Thomas Taylor, of Manchester, which forms the subject of the present paper, appears to contain all the essentials of a complete and correct meter.

A meter is required to sustain the greatest pressure,—the flow must not be interfered with by obstruction or friction, so as to hinder its ascent to the highest point of its source,—it must measure correctly under every variety of pressure, and when subdued to the smallest amount of inlet must indicate the quantity passing through the meter,—and durability or non-liability to wear and tear must be an important feature, without which the machine would be of little value.

It will be seen that these properties are all embraced in the meter of Mr. Taylor, and that it is admirably adapted to answer all the purposes for which water meters have been designed. In consequence of water being almost incompressible, the amount of water contained in a pipe or vessel of a given dimension must be the same under all pressures, and therefore if a machine could be constructed that would indicate correctly the speed at which the water flows through a pipe of a given area, the quantity might be ascertained to the greatest nicety. In Mr. Taylor's meter, now to be described, this object has been achieved.

The idea that struck him for ascertaining the quantity of water passing through the machine was as follows:—He first determined the area of the pipe through which the water was to flow (say equal to two inches diameter), and in the next place the circumference of the wheel or drum that was designed to move simultaneously with the flow of water (say 24 inches circumference). The next question would be, how much water will a 2-inch pipe contain in 24 inches length; and supposing this to be one gallon, then in that case every revolution of the wheel or drum would indicate one gallon as having passed through,—ten revolutions would be ten gallons, and so on, the index being set so as to register the exact quantity passing through the meter at each revolution.

The Meter, which is shown in Plate 38, consists of a cylindrical vessel or cistern AA, of a size proportionate to the bore of the pipe that is to receive and discharge the water; inside this vessel is a drum B revolving on its axis in a vertical position, and the stream of water passing through the meter is distributed upon the drum at each side of the meter, the water entering at the two inlet openings CC, and being discharged at the two outlets DD. The registration is given by a train of wheels at E, connected with the drum, and carried to the indicator K.

The drum is constructed of gutta-percha, thereby preventing liability to collapse or corrosion, and making it of the same specific gravity as water. The water contained in the meter causes the drum to be buoyant, by which arrangement the drum is made to revolve by the slightest action of the water against the blades or buckets.

The arrangement of the thoroughfares or pipes FF outside the

meter, communicating with the inside and round the drum, for the delivery and exit of the water, produces a rotary motion in the water, thereby causing the drum, in addition to its buoyancy and vertical position, to be more certain in its liability to revolve under the slightest pressure of water.

The branch pipes and valves GG from the thoroughfares for the ingress of the water, are so shaped that they bring the immediate action of the stream passing through the meter on the drum. The equal distribution and division of the stream (however small it may be) at each side of the drum, render its liability to wear and tear very slight; and whatever the pressure or power of the stream may be, by the above arrangement it is rendered neutral in causing more or less friction upon the axles or pivots of the drum, that friction being the same under any pressure, and only sufficient to keep the drum in its position.

The valves GG (shown enlarged in Fig. 3), are constructed after the plan of a common clack valve, and close the apertures of the inlets, excepting a small tube H fixed in the centre of the clack, and projecting so as to cause the stream of water to come into immediate contact with the buckets of the drum. Each valve is closed by a simple arrangement of a small india-rubber spring I, attached to an eccentric above the valve, the spring being regulated by winding it backward or forward on the pin L (which being once regulated becomes a fixture, and needs never to be altered), so as to give more or less pressure to close the valve. The use of these valves is occasioned by the fact that although the pressure on the drum may be neutralised, yet there is necessarily a slight amount of friction to overcome in working the train of wheels to the indicator, which is done by the spring closing the valve, and causing a compression of the stream, so that no water is allowed to pass but what forces through the valve-tube H. The valve is only brought in requisition when a very small quantity of water is passing through the meter, and as the stream increases the valve is not required to insure correct measurement; it is then thrown open by the vanes MM, which are fixed on the valve spindles, and are carried outwards by the circulation of the water in the meter, when there is a considerable stream passing through.

The certainty of registration of this meter, its non-liability to wear and tear, and its certainty of working under the highest or lowest pressures, are caused by the buoyancy of the drum, its vertical position, and the adaptation of the inlet-pipes and compression-valves to bring the stream, however small, into immediate contact with the drum, and cause it to revolve.

Meters on this construction, of various sizes, and placed in different situations, have been in operation for several months; and the inventor has been furnished with several testimonials of their efficiency.

Mr. Fothergill showed one of the meters in operation before the meeting, which had been brought by Mr. Taylor for the purpose, and exhibited separate specimens of the gutta-percha drum and regulating valve. He observed that the friction of the drum was very small, as its weight was all supported by the water, being adjusted to the same specific gravity as the water, and the resistance from friction of the wheelwork, and the stuffing box for the spindle at the side of the meter, would be very slight, on account of the great leverage over it at which the water acted on the circumference of the drum; there was consequently so exceedingly small a resistance to be overcome in making the drum revolve, that the smallest stream of water impinging on the drum and flowing round its circumference was sufficient to overcome its inertia, and cause it to rotate with a velocity proportionate to the quantity of water discharged, being the amount of moving force. The velocity with which the circumference of the drum revolved, was consequently a correct measure of the quantity of water discharged upon it; and this had been found to be the case in practice, for all the meters had been worked under very extreme differences both in pressure and in velocity of discharge, and those he had examined or was acquainted with had proved correct in measurement throughout. The meters had been used with great advantage to measure the quantity of water supplied to boilers, so as to ascertain correctly the water evaporated by the coals consumed, which was important information in reference to economy of working, and could only be satisfactorily ascertained by means of such a meter.

Mr. THOMPSON said he had had three of the meters at work for several months in Manchester; one a large meter to measure the water raised into a 3000 gallon cistern, and two others employed to measure the water supplied to boilers. He had tested the meters regularly once a week for some time, and found that they uniformly registered correctly within one half per cent.; they had kept in good order, and gave entire satisfaction.

The CHAIRMAN remarked that he had recently witnessed a trial of the meter with several members of the Institution, in which the meter was connected to a cistern containing 100 gallons of water to about ¾ inch depth; the register of the meter was found to be correct for each 100 gallons drawn from the cistern, both when running full bore and when discharging only by a very small stream. The meter appeared therefore to be accurate under both extremes, and he thought it was a very ingenious invention, and had an important advantage in the simplicity of construction.

Mr. PERRING said he had tried a series of experiments on four different meters, and this was the only one that he found not to fail in registering the quantity of water when discharged in a very small stream.

Mr. ROFE inquired what was the highest pressure under which the meter had been tried?

Mr. FOTHERGILL replied that one of the meters was working under 220 feet head of water at Bolton, and was found to work quite satisfactorily. The largest of the meters that had been made, was at Dukinfield, where it was supplying 72,000 gallons per hour.

Mr. ROFE inquired what examination was found to be required after the meters had been in regular work for a considerable time? and whether there was any effect upon the gutta-percha drum and the india-rubber spring from the action of the water? He should fear the india-rubber spring was too delicate for such a purpose.

Mr. FOTHERGILL said that after one year's constant work both the gutta-percha and india-rubber were found to remain perfect and unaltered, and he saw no reason to doubt that the experience of further years would give the same result; the water did not have any action upon them; it would not however do to have a gutta-percha drum with hot water, and in applying the meter to measure the supply of water to boilers, care must be taken that it was not exposed to water warm

enough to soften the gutta-percha. If the meter were required to measure hot water, a hollow copper drum should be used.

Mr. Thompson observed that he had a meter with a copper drum in constant use for some time measuring hot water, and it had proved quite successful.

Mr. Rofe asked whether there was any reason besides its lower cost for using gutta-percha rather than copper in making the drum?

Mr. Fothergill replied that independent of the cost being less, the gutta-percha had an advantage in the convenience and accuracy with which it could be manufactured; it was pressed into an iron mould, accurately made to the form of the drum with all the teeth, and the sides being then stuck on completed the drum.

Mr. Shipton remarked that a copper drum might also be objectionable, from being made accidentally out of balance, by a lump of solder left in one part.

Mr. Cowper said he did not see how the measuring of the water could be effected by the meter with sufficient certainty, as the measurement was not made by filling the buckets successively in the circumference of the drum, they being already full of water, but only by the velocity communicated to the wheel by the stream of water flowing past it; and he did not think the measuring could be accurate at different velocities, as the friction would not be constant, and therefore the difference between the velocity of the wheel and that of the water would not be constant.

The Chairman observed that it appeared to be considered that the buckets or teeth on the drum were carried forward and floated with the stream at the same velocity as the stream, in consequence of the very little resistance to retard the drum. He was certainly surprised at the accuracy of the results obtained in the experiments with the meter, and thought it well worth a complete trial, as a simple and ingenious machine; and he proposed a vote of thanks to Mr. Fothergill and to Mr. Taylor, which was passed.

The following Paper, by Mr. Edward Jones, of Liverpool, was then read:—

ON THE AMERICAN DRY CLAY BRICK-MAKING MACHINE.

This Machine, the invention of Mr. Culbertson, of Philadelphia, is one of the numerous American inventions imported into this country, and has been worked in a most satisfactory manner for a considerable period, in several parts of the United States. The simplicity of construction of this machine, and its complete adaptation to the intended purpose, are the writer's reasons for bringing it before the meeting. It will be seen from the drawings and model that there are few wearing surfaces in the machine, and they are not likely to get out of order.

A longitudinal section is shown in Fig. 1, Plate 36, and transverse sections in Figs. 2 and 3, Plate 37.

A is a strong cast-iron frame, fixed to a brick or stone foundation.

B, a portion of the frame for receiving the journals of the press-wheel and roller shaft.

C is the mould carriage, containing 14 moulds, each provided with a moveable bottom, with stems projecting through the carriage, by means of which, and the lifting bars D, the bricks are raised from the moulds, as the lifting bars D are carried up the inclines E E on friction rollers by the forward motion of the carriage C.

F, slides for bearing off, which in the working machine are made self-acting.

G is the rack, bolted to the bottom of the carriage, worked by the spur-wheel H.

I I is the clay box, fitting close on to the face of the mould carriage, and secured to the frame.

K K, the hopper.

L, the press-wheel.

M, bearing wheels, to sustain thepressure on the mould carriage.

N N are two spur-wheels to cause the press-wheel and mould carriage to travel at uniform rates.

O is an internal and external spur-wheel.

P is the pinion on the vibrating shaft, producing a reciprocating motion of the mould carriage, by what is generally known as the mangle motion.

A steam pipe is provided, marked Q, which can be used if it is found necessary, to warm the press-wheel, which is cast hollow, to prevent the clay adhering to the surface.

This machine enables the manufacturer to continue his operations during the whole of the year, as the clay used is in a semi-dry state, or just as it is dug from the ground, and the bricks when made are taken direct from the mill to the kiln.

The machine is self-feeding and self-delivering, and will, with ease, turn out 25,000 bricks per day, harder, smoother, and containing less water, than when made by hand, and at a much less cost. Instead of the present mode of casting, tempering, weathering, &c., the clay is taken direct from the bank to a pair of rolls running at different velocities, so as to break it up thoroughly, and from thence to the mill by means of elevators or other mechanical appliances.

The pressure upon the clay in the machine is gradual and continuous, allowing the air to escape freely as the clay is forced into the mould; and as each mould passes twice under the cylinder, receiving clay from the hopper each way, the brick is made full and perfect in all its edges.

Bricks of any shape can be made with this machine by using suitable moulds.

In a commercial point of view, the following statement will show the value of the invention.

The present prices of brick-making in Lancashire are:—Casting 10d., faying 2d., moulding 1s. 8d., tempering 1s. 8d., wheeling off and walling 1s. 8d., carrying off 9d.; making a total of 6s. 9d. per thousand.

Taking the working days at 250 in the year, an average of 25,000 per day is equal to 6,250,000 per year, costing at 6s. 9d. per thousand, £2104 7s. 6d.

By means of the machine we have:—First cost, including steam engine, foundation, crushing rolls, and all other machinery required, £1400.

	£	s.	d.
This at 15 per cent. for interest and depreciation is	210	0	0
Coal, oil, and engine driver, for 250 days	190	0	0
Getting clay and wheeling to rolls	190	0	0
Wheeling off, and attending to machine	200	0	0
Incidentals	50	0	0
	£840	0	0

or 2s. 8½d. per thousand, or a gross amount of saving of £1264 7s. 6d. on the year's work; being nearly the entire cost of the whole of the machinery and buildings.

Mr. JONES exhibited a working model of the machine, with full-size specimens of the bricks, baked and unbaked.

The CHAIRMAN inquired whether the pressure upon the bricks in the machine could be varied, if required?

Mr. JONES replied that it could only be done by adjustment of the wheel; the form and size of the press-wheel regulated the drawing in of the clay under the wheel and the degree of pressure into the moulds.

Mr. H. SMITH asked how long the machine had been at work?

Mr. JONES said it had been working for nine years in the United States, where machine-made bricks were used to a large extent on account of the greater cost of labour; the machine had only been a short time at work in this country. The comparative calculation of cost given in the paper was founded on the rates of brickmaking in the last season at Wigan.

Mr. DYER thought there would be great objections raised in that neighbourhood to making bricks otherwise than by hand labour; the prejudice was so great amongst the labourers against the introduction of any new machinery, lest it should supersede their employment.

Mr. JONES remarked that this machine would be a great advantage to the brickmakers, because they could be employed for the whole year continuously, as the bricks did not require drying; but it was now a very precarious employment, being dependent on the season and weather. There was now one of the machines at work at Kirkdale, near Liverpool, making excellent bricks in all weathers, specimens of which were before the meeting.

The CHAIRMAN said he trusted that the opposition to the introduction of machinery was now rapidly disappearing, being only the effect of ignorance; and it was becoming more generally understood that the farther the introduction of machinery into a manufacture was carried, the more manufacture would thrive and increase. He inquired what was the comparison of the number of bricks per day that could be made by hand-labour and by the machine?

Mr. JONES replied that the machine turned out 25,000 bricks per day, and a good brickmaker made 6,000 or 7,000 per day; but these had all to be dried before they could be burnt, and it was a great advantage in the machine-made bricks that they did not require drying, but were taken direct from the machine to the kiln, making an important economy of time, as well as preventing the great waste that occurs from injury of the bricks when exposed to the weather.

The CHAIRMAN proposed a vote of thanks to Mr. Jones for his communication, which was passed.

The following paper, by Mr. Benjamin Fothergill, of Manchester, was then read:—

ON THE COMBING OF FIBROUS MATERIALS.

In investigating the various mechanical contrivances for combing fibrous materials, a reference has necessarily to be made to those instruments which the ingenuity of man originally contrived for the accomplishment of this object, and there appears no doubt that the common or ordinary comb, made sufficiently long and strong in the teeth, was first used for this purpose; the defects of that instrument, however, would soon become apparent, and the necessity for additional numbers of rows of pins or teeth would naturally present itself, so that the operator might be able to collect and hold the various lengths of the fibres of the wool as he lashed or looped them on to the teeth of the comb.

Such was the state of things when the Rev. Edmund Cartwright, of Doncaster, in Yorkshire, (a name ever to be revered and respected) turned his attention to the subject, and contrived a machine for combing wool, for which he took out his first patent in 1790, and a second in the same year; but it was not till nearly two years afterwards that his machine was brought to what he called "its state of simplicity and perfection," for which he took out a third patent in May, 1792. Concerning the latter he says:—"This machine is I believe the first of the kind; at least, all former attempts (if there have been any) must have proved abortive, as previous to my invention, no wool was ever known to have been combed any other way than by the slow and expensive process of hand labour."

The magnitude of this invention in respect of its object and its importance to the Woollen Manufacturers, may in some degree be estimated

by the quantity of combing wool annually grown in this island, which according to the most approved calculations cannot be less than 300,000 or 400,000 packs: the average expense of combing which by hand may reasonably be laid at £800,000 or £1,000,000. To show that this calculation is not far from the truth, it need only be recollected that the body of wool-combers is supposed to be nearly 50,000, among whom the alarm which the introduction of this machine has occasioned is well known: upwards of 40 petitions, from various parts of the kingdom, were presented to parliament during the course of the present session, for its suppression: and for this purpose a bill was brought into the House of Commons by the friends of the petitioners; it was however thrown out by a great majority: indeed, had the principle of the bill been admitted, there would have been an end to all manufacturing improvements; but setting even this consideration aside, on other principles of policy, it would have been inadmissible; and even on the principle of humanity to the petitioners, the only ground on which it could be defended, there is reason to believe it would not have been necessary, the introduction of new inventions or improvements, whatever may be their value, being in general so gradual as to affect those whose occupations they interfere with almost imperceptibly.

The drawing of this interesting machine, shown in Plate 34, is copied from the original one in the Patent Office. Fig. 1 is the crank lasher (a contrivance intended to supersede the man's arm and hand in lashing the wool into circular combs). A a tube through which the material, being formed into a sliver, and slightly twisted, is drawn forward by the delivering rollers E. B a wheel fast upon the cross-bar of the crank. C a wheel on the opposite end of whose axis is a pinion working in a wheel upon the axis of one of the delivering rollers.

When two or more slivers are required, the cans or baskets in which they are contained are placed upon a table under the lasher (as represented at D), which, by having a slow motion, twists them together as they go up.

In Fig. 2, F is the Circular Clearing Comb, for giving work in the head, carried in a frame by two cranks W W.

G G, the Comb Table, having the teeth pointing towards the centre, moved by cogs upon the rim, and carried round upon tracks like the head of a windmill.

H H, the drawing rollers. I I, callender or conducting rollers.

Under the table is another pair of rollers for drawing out the backings, but these are not shown.

Such is a description of Cartwright's machine, of 1792, and it is a singular fact that although he patented another machine in which considerable improvements were introduced, yet he did not perceive the great evil which existed not only in his own machines, but also in the mode of treating the wool by the *hand* comber; and although a great number of patents have been taken out for improvements in machinery for combing wool from the time of Cartwright to the present period, yet all of them up to the year 1846 continued to overlook the fact that in the process of combing the majority of the fibres were broken in two, producing not only more "noil" or waste, but considerably shortening the otherwise long fibre; and although they had the practice of the hand flax-dresser, as well as the improved machines for heckling or combing flax before their eyes, yet they did not discover or attempt any means to remedy this serious defect.

This was the state of things when, in 1846, Josué Heilmann, of Mulhausen, in France, introduced his improved machine "for the purpose of combing cotton as well as wool and other fibrous materials; into which machine the fibres as they come from the dressing machine are introduced in the form of a lap, sliver, or fleece, which is broken asunder, and the fibres are combed at each end, and the long and short fibres are separated, the long ones being united in one sliver, the short ones in another; and they are passed out of the machine thus separated ready for drawing, roving, and other subsequent operations."

A drawing of Heilmann's machine is shown in Plate 35, in which Figs. 1, 2, and 3 show three successive positions of the moving parts.

The object of the machine is to avoid the old and injurious process of "lashing" the fibres round the teeth or pins of the combs, and the contrivance to effect this object is as follows:—The end of a "sliver" of uncombed wool A is delivered into the machine, and the front end B of this sliver is combed by the pins C C fixed on one portion of the surface of the revolving cylinder D, whilst the entire mass of the sliver is held tight between the holding "nippers" E F, as shown in Fig. 1; which shows the position of the machine when the combing by the pins

C C is just commencing. After these pins have combed out the short fibres and other refuse from the sliver, the nippers E F open, as shown in Fig. 2, and at the same moment the moveable comb G is made to pierce through the sliver, by the pins H H lifting the lever attached to the arm of the comb; and the drawing roller I coming at the same time into contact with the fluted portion K K of the cylinder D, lays hold of the front portion B B of the fibres (which have been combed), and draws the uncombed portion through the fixed combs L L and the moveable comb G, thus effecting a combing of the tail-end of the portion of the sliver which is thereby detached.

The machine is then made to pass another portion of the sliver forward from A, by the action of the cam M, which draws back the nippers towards the fixed comb L, as shown in Fig. 3, when the nippers are closed and pulled down by means of the lever N and rod O; and the cam M having passed into the position of Fig. 1, the lever P which vibrates from a fixed centre R and carries the nippers by the centre S, returns to its original position as in Fig. 1, causing the nippers to draw forward another length of the sliver from A. The entire process being repeated with the succeeding length of fibre, another portion is combed and detached, and is carried forward by the drawing roller I. and pieced on to the preceding portion; the combed wool leaves the machine in a continuous sliver, passing through the calender rollers T T, into a can U, from which it is taken to the after processes of drawing and spinning.

The pins C C on the cylinder D are cleaned by a revolving brush V; and the short fibres and refuse are delivered and struck into the card teeth on a revolving roller W, from whence they are "doffed" by the knife X.

Thus in this way the fibres are combed and laid parallel by the side of each other without being broken; and to such perfection has this machine been brought, that not only some kinds of wool which could not be combed by machinery prior to Heilmann's invention, but cotton, silk, and tow are now undergoing this new mode of treatment with decided advantage and complete success: and the accompanying specimens laid before the meeting will show the difference between the ordinary carded cotton and the combed cotton. Besides, this machine can be so constructed as to take out different lengths of fibre from one

sample of material, as shown in the accompanying samples of silk, and during the first operation it selects all the longest fibres, which are the most valuable; the remainder are then put through the next machine, which has the nippers and rollers placed closer together, and a second, though shorter class of fibres are combed and selected; it is again submitted to a third operation, and the shortest length is selected, and the remainder, it will be observed, is nothing but "noil" or waste. Such is the character of this beautiful invention, which is well deserving of consideration; and it may be observed that this machine is now being introduced into the Manchester cotton mills, where the higher classes of numbers are spun.

Mr. FOTHERGILL exhibited a series of specimens, from France and Yorkshire, of cotton, flax, and silk, illustrating the process of combing, and the various degrees of fineness in quality that could be produced; and showed the effect of looping the material over the teeth of the comb and breaking the fibres as in the old process of combing, and the superior result of drawing out the long fibres unbroken by the improved process of Heilmann described in the paper. He stated that previously nothing farther could be done with the refuse tow left from combing flax, beyond carding and spinning it into a coarser class of yarn; but by the improved process as great a value could be obtained from that refuse by additional combing as was obtained from the first combing by the old process.

Mr. DYER said he had witnessed the operation of the machine at Mr. Houldsworth's mill, and was very much struck with the perfection with which the machine selected the long from the short fibres; it was certainly a highly ingenious and important improvement in the process of combing, and appeared likely to make a great change in the treatment of fibrous materials.

Mr. FOTHERGILL remarked that one great advantage in the improved process was that the fibres obtained were all of the same length, but there used to be a mixture of many different lengths, on account of the fibres being so much broken in the combing; also this machine could be so arranged as to select all varieties of length of fibre without

breaking them, and he had known as many as seventeen different lengths of cotton picked out from one sample. The uniformity obtained in the length of fibre was an important advantage in spinning, and it was attracting great attention in the spinning districts.

The CHAIRMAN observed that the new combing machine was a very beautiful mechanical invention, intended to perform a delicate and difficult process, and it appeared to be quite successful in accomplishing that object, by effecting a very important improvement over the former process. He proposed a vote of thanks to Mr. Fothergill, for his valuable and interesting paper, which was passed.

The following paper, by Mr. William Fairbairn, of Manchester, was then read:—

ON THE RETARDATION AND STOPPAGE OF RAILWAY TRAINS.

The general principle of railway-carriage breaks, namely, that of retarding or stopping the revolution of the wheels by the pressure of break-blocks against their peripheries, is limited in its application to the single carriage, in which the power is applied by the guard's hand; and looking at the present greatly-increased velocities of trains, and their probable acceleration, it becomes a very important question, whether some more powerful and speedy control is not required over the motion of the train than can be obtained by the ordinary plan of a break upon one or two guards' vans, and upon the tender.

Many plans have been proposed during the progress of the railway system for the accomplishment of this desirable object, and amongst them may be mentioned, as one of the most practical, a plan invented some years since by Mr. Robert Heath, of Moss Side, near Manchester, which consisted of break-blocks fixed in slide-bars in each carriage, and worked by a lever with a weight upon the end of it, adjusted to give the requisite pressure upon the wheels. When the pressure of the breaks was required to be taken off, the ends of the levers were lifted by means of a tension-bar and chains, which extended the whole length of the train, and were worked by a rack and pinion within reach of the guard. The peculiar feature in this break, distinguishing it from the ordinary hand breaks, was the employment of a weight to put on the pressure of

the breaks, independent of the power of the man's hand, and simultaneously in every carriage of the train, giving an important advantage in the great increase of power available for stopping the train, and the promptness of its action, the guard having only to release a catch in order to put on all the breaks at once, and employing his own power only in lifting off the breaks afterwards, by means of the rod and chain communicating with each carriage. In a practical trial of these breaks in 1848, with a train of five carriages and a van, all fitted with the breaks acting together, and the tender-break also used, the following results appear to have been obtained:—

Speed of Train when Breaks were applied.	Descending gradient.	Distance run after Breaks were applied.
40 miles per hour.	1 in 100	148 yards.
45 " "	1 in 100	163 "
50 " "	1 in 82	232 "
55 " "	1 in 200	264 "

Numerous other plans have been suggested, and tried at different times, for the purpose of arresting the motion of railway trains, within shorter distances than can be effected by the ordinary hand breaks; but none of them appear to have answered the purpose satisfactorily, or effected any material change in the breaks in general use.

The next improvement requiring particular notice, is the break recently invented by Mr. James Newall, of Bury, the more immediate subject of the present paper.

The immense extension of railway communication, and the number of persons conveyed, involve considerations of such vast importance, as to render any attempt to obtain increased security a subject of deep interest, in whatever form or direction that security can be effected. If the causes are considered of the railway accidents which from time to time take place, they may, in many instances, be traced to those arising from the inability to bring a train from a state of motion to a state of rest, or in other words, to absorb the momentum of the train within a given distance of space, and that without injury to the carriages, or endangering the safety of the passengers. This has always been a defect in railway travelling, and many of the serious accidents arising

from collisions of one train running into another, have occurred from the want of power to stop the train in motion before it arrived at the point of contact.

This to some extent has been accomplished by Mr. Newall's break, and from the results of the experiments made on the East Lancashire Railway, on the 7th November last, as described subsequently, this break appears to bid fair to accomplish that object, or at all events to become the precursor of further improvements, giving increased security to railway travelling.

The following is a description of Mr. Newall's break, which is shown in Plate 39 :—

The object of this invention is to work as many of any description of breaks as the weight of a train may require, either from the engine or guard's van, or from any of the carriages in the train. A lever, A, is fixed to the centre shaft of the break, under each carriage, to extend to the end of the carriage; the length of this long lever, as compared with the short arms which apply the break-blocks to the wheels, is about 11 to 1. A cylinder, B, is fixed to the end of each carriage, containing a spiral spring, which will shut up inside the cylinder to 14 inches length when compressed; under this spring is placed a cross-head, C, which projects out of the cylinder at each side, and is acted upon by the spiral spring; this cross-head is connected to the end of the lever A, and the spring gives a pressure of about 56lbs. at the end of the lever, which multiplied by the leverage, 11 to 1, gives a pressure on the four wheels of about 616 lbs; this pressure is found sufficient for ordinary stoppages. Two upright racks, DD, are connected to the cross-head, C, and they are acted upon by a pinion, E, fixed on the main shaft at the top of the carriages; only one of these racks is in action at a time, but two racks are used, because when a carriage comes to be connected, and is the wrong end about, one rack can then be thrown out of gear, and the other into gear, so as to reverse the motion, which is done by sliding the frame carrying the pinion E, by means of a small lever at the top of the carriage. The connecting shaft F is carried on to each carriage, and on to the tender at G; and if the guard's catch is on, in his van at H, the engine-driver, by giving a lift at the handle G, as if taking the breaks off, liberates the guard's catch, and

so *(vice versa)* all these catches are made to fall back from the ratchets by balance weights (as shown enlarged in Fig 5), on the weight being taken off them; as soon as the catch is fallen back, the guard or driver lets go the handle, and the breaks apply themselves by the pressure of the springs, but the guard or driver can apply as much more pressure as he thinks fit by giving the handle a few extra turns The coupling of the shaft F between the carriages is effected by a spring catch T, similar to a brace and bit, as shown in Fig. 3. A man can couple and uncouple six carriages in as many minutes; each coupling is made to offer either end by means of a swivel joint, so as to couple with the next carriage, whichever end may be put to it. Five or six turns of the handle on the tender or van are sufficient to apply the breaks, or take them off, and one guard can work six of them easier and quicker than one of the ordinary breaks. After the train is marshalled in the usual way, the porter drops all the breaks on, and then mounts the carriage and couples each; in addition to the spring stud on the opposite side of the coupling, a thumb-screw is used as an additional safety. When all are coupled together the apparatus can be worked from any portion of the train, or from the tender; the shaft T which passes along the top of the whole train is made of 2½in. iron tubing, about ¼in. thick, and revolves in light cast-iron pedestals, and on each carriage it is made with an expanding slide M of 1¼in. square iron, working in a steel square, welded in the end of the other tube; the steel square is about 2½in. long, and the square bar 6ft. long. If the shackle becomes broken this square bar is drawn out of the tube, and the breaks instantly are liberated and apply themselves. Double ball-and-socket joints NN are provided at each coupling, to allow for differences in the heights of the carriages, and curvature of the trains.

In addition to the advantage of being able to stop the trains in so much shorter a time, a saving of 70 per cent. is stated to be found in the wear of the tyres; this saving in wear is effected by not having to skid or stop the revolution of the wheels, so as to cause them to slide on the rails. Trains are being also fitted up with the connections running under the carriages, but the principle is the same; the connection underneath being sometimes preferred as more convenient for carrying it past carriage-trucks, horse-boxes, &c.; if the connection is to be carried over the tops, the carriage-trucks require a frame at each end to support the rod; the connection can easily be taken over the horse-

boxes. The breaks need not be applied to every vehicle in the train, if desired, the coupling-rod only being required to be continued throughout the train, which then acts as a perfect signal for communication between the guard and engine-driver when there is danger of a collision.

The following objects are proposed to be obtained in this break :—

1st.—A direct communication between the engine-driver and the guard; and it has to be observed that this communication is always available by either party, in the event of a sudden and unexpected discovery of danger or obstruction upon the line, and this accomplished, not by ringing a bell or blowing a whistle, where time is lost before the break can be applied, but by on instantaneous application of the break itself, or rather the whole of the breaks, which in every case is the first intimation of the presence of danger, and the remedy to avert its occurrence. This appears to be an important feature in the plan, it is easy of application, and probably the best signal that can be made between two officers of such responsibility as the driver and guard. In the experimental trial of this break, this was an important feature, and one that could not be mistaken at the moment the breaks were liberated; the check (it could not be called a shock), was so distinctly felt, as to arouse the attention of less vigilant persons than guards and drivers, who are, or should be, constantly on the look-out.

2nd.—The instantaneous and simultaneous application of the break to every carriage in the train; and the immediate application of a retarding power to a body of such magnitude as a train in motion, and that without endangering its security, is an advantage of great importance in this plan. The breaks are not screwed against the peripheries of the wheels, as is done in the usual way by the guard in the carriages, and the fireman on the tender; but the whole of the breaks (even if 30 in number), are dropped at once upon the wheels, and by the expanding force of the springs in the vertical tubes, the effect is such as to act as a signal from the driver to the guard, or *vice versa* from him to the driver; no time therefore is lost, and the retarding force is in operation upon every carriage at one and the same time, and by this operation a few

seconds only are required to reduce the velocity and absorb a considerable portion of the momentum of the train. This simultaneous action is therefore of the utmost importance, particularly in the event of a threatened collision, which by this means, if not totally averted will assuredly be greatly mitigated in its effects.

3rd.—The power which either the engine-driver or the guard have together or separately to sledge the train, or to increase or diminish the pressure on the breaks. In applying this plan of breaks to a railway train, particular care is required in the first instance when the train is marshalled, to regulate and adjust the breaks upon each carriage, so as to give neither more nor less than the required pressure. This it will be observed is a constant quantity, and the remaining pressure when required must be applied by the driver or guard; and as time is an element in this application there is the less danger of its being injuriously applied, even when extended to the limit of sledging the train, or stopping all the wheels. This power of application is however necessary, as the same amount of friction could not be applied with security to the train by the force of the spring, without incurring risk in the breakage of the wheels or axles.

The following are the particulars of the experiments made upon the East Lancashire Railway, to ascertain the retarding power of Mr. Newall's break, in stopping railway trains. The train in each case consisting of 10 carriages, besides the engine and tender, with a gross weight of 88 tons, including the engine and tender.

No. of Experiment.	Descending Gradient.	Speed of Train when Breaks were applied.	Distance run after Breaks were applied.	Remarks.
1	1 in 532	38 miles per hour	218 yards	Rails moist & slippery
2	Level	33 „ „	100 „	Bury, rather doubtful
3	1 in 38	45 „ „	430 „	Accrington Incline
4	1 in 40	48 „ „	371 „	Ditto ditto
5	Level	48 „ „	192 „	Blackburn, two wheels
6	Level	40 „ „	138 „	Ditto, five do. [sledged
7	Level	50 „ „	310 „	Ditto
8	Level	42 „ „	620 „	Blackburn, 3 wheels sledged
9	Level	40 „ „	800 „	Ditto

The experiments 1 to 7 were made with 8 of the carriages in the train fitted with Newall's break, besides the ordinary tender break; and the experiments 8 and 9 were made with ordinary breaks, 2 carriages boing fitted with them in No. 8, and 1 in No. 9.

In the experiments 5 to 9, more particular care was taken to ascertain the speed by time and distance, and the moment at which the breaks were to be applied was marked more definitely by the explosion of a detonating signal at the point fixed.

The general result of these experiments appears very favourable to Mr. Newall's break, as to the efficiency of its retarding power compared with those in ordinary use. At 40 miles an hour, upon a level, with the improved break the train was brought up in a distance of 138 yards, but with the ordinary breaks, at 42 miles an hour, 620 yards was run over before the train could be stopped; or in other words a railway train can be stopped in one-fourth the distance.

Another plan has been proposed by Mr. Samuel Newton, of Stockport, for attaining the same object of putting on the breaks in the train by self-acting means. To accomplish this a friction-wheel, 2½ feet diameter and 10 inches broad, is proposed to be fixed on the centre of each axle; this friction-wheel is to be surrounded with an ordinary clamp break, such as is generally used in connection with cranes, consisting of an expanding steel ring, lined internally with wood. One end of this break-ring is fixed to the carriage frame, and to the other end is attached the short arm of a lever, so that when the long arm of the lever is raised the ring is by this motion enlarged a little in diameter to allow the friction-wheel to revolve within it without being touched. The long arm of the lever from the front axle approaches that from the hind axle, and both meet under the centre of the carriage; here the levers are joined by a bolt with a slide, so that they may rise and fall together. A weight is then attached, the tendency of which is to depress both levers, and to cause their respective short arms to collapse each break-ring tightly round the friction-wheel, and thus arrest its revolution, and with it that of the axle and wheels. This is proposed to be the arrangement for every carriage, the weight on the levers between each pair of wheels being about 120lbs. By force of gravity the breaks will apply themselves, and the power to be exerted must be

for the purpose of taking them off. This is proposed to be done by the pull of the engine, by means of a metal rod with joints, which passes under all the carriages in a train, and is placed in connection with the weighted levers. The first end of this rod is to be joined to the tender, and when the engine starts it will draw out the rod so as to lift up all the levers, and thus release the breaks from the friction-wheels, and keep them clear so long as the engine continues its tension upon the draw-bar. By this arrangement it is contemplated by the inventor, that in order to stop the train it will simply be necessary to arrest the speed of the engine, and that the draw-bar will then slide backwards by the action of the weights, which will at the same time depress the levers and apply the breaks.

In another plan for accomplishing a similar object, recently proposed by Mr. Alfred Molson, of London, the application of the breaks is proposed to be effected by means of a break-bar sliding longitudinally under each carriage, acting on the levers of the break-blocks, and projecting at each end of the carriage as far as the buffers, so as to come in contact with the ends of the break-bars of the adjoining carriages.

On a check being given to the engine, and its speed being retarded by applying the break to the tender, the hindmost carriages of the train will press on those preceding them, and the springs of the ordinary buffers giving way, the train will be thereby shortened some inches while the break-bar of each carriage remaining of its original length, and resisting the advance of the carriages behind, it will follow that the last two or three carriages will have the breaks put on before even the guard in the van has turned the handle of his break.

The two latter plans not having been yet tried, except in models, no practical results can be given, and they have been named with the view of bringing under the consideration of the members the important subject of the prevention of collisions of railway trains, by increasing the retarding power of the breaks.

A large working model of Mr. Newall's Railway Break was exhibited and shown in action; also a model of Mr. Newton's Break.

The Chairman observed that he had been much struck with the very prompt and instantaneous action of Mr. Newall's break when he wit-

nessed the recent trial of it upon the East Lancashire Railway; it would be an important auxiliary in preventing collisions if the means were always at hand for stopping the trains in so short a distance, and this break appeared well suited for the purpose, if it did not get out of order, and was not too expensive.

Mr. PERRING said he had observed the working of these breaks during three months' daily work on the East Lancashire Railway, in which time they had travelled 9400 miles between Manchester and Colne, with 4811 stoppages, being stopped at a station every two miles. There had been no case of the breaks being out of order during this trial, and they had been found to work quite satisfactorily and efficiently; he had recently examined them and found the whole apparatus was standing well; the break-blocks were worn down much less than usual in the time, on account of the greater number of them that were in action at once, and the wheel tires were found to have worn only about 1-10th of an inch in the time, as shown by the templates of the tires exhibited. There were three trains running with these breaks on the East Lancashire Railway, and he should be glad to show them in operation to any of the Members who might wish to examine their action.

The CHAIRMAN inquired what would be the expense of applying Mr Newall's plan to the present railway carriages?

Mr. NEWALL replied that the cost of applying it to the present break-carriages would be about £9 per carriage; but he did not think the extra cost would exceed £5 per carriage in the case of building new stock.

The CHAIRMAN observed that the principle of the break had certainly a great advantage in the promptness with which the breaks in the train could be all put on simultaneously, either by the guard or the engineman in the moment of emergency, as the springs had only to be released at the moment the breaks were required, and there was always plenty of time afterwards for drawing them up again. The break handle also gave the means of direct communication between the guard and the engineman, free from interruption.

He inquired what would be the cost of Mr. Newton's break? and how he proposed to provide for backing a train without causing the breaks to be put on? He did not see how that could be accomplished by his plan.

Mr. NEWTON replied that he thought the extra cost would not exceed £3 per carriage. When the train was backed there would be a means required for holding the draw-bars so as to prevent the breaks being put on, also to give the guard the means of putting on the breaks; the plan had not been completed yet in this respect, but he thought it was practicable to accomplish the object.

Mr. DYER remarked that there would be a disadvantage in having a weight instead of a spring for acting on the break, as there would be the weight to be carried, and its action would not be so steady as a spring.

He proposed a vote of thanks to the Chairman for his paper, which was passed; and to Mr. Newall and Mr. Newton for the models they had brought before the meeting.

Mr. COWPER proposed a vote of thanks to the Council of the Royal Institution for their kindness in granting the free use of their Lecture Theatre for the meeting.

The motion was seconded by Mr. Jones, and passed.

The meeting then terminated.

The following paper, by Mr. Andrew J. Robertson, of London, was read at a previous meeting (see Proceedings, Institution of Mechanical Engineers, 1853, p. 72), but the publication has been delayed in consequence of the absence of the author from the country.

ON THE MATHEMATICAL PRINCIPLES INVOLVED IN THE CENTRIFUGAL PUMP.

In a paper by the writer at a former meeting (see Proceedings of the Institution of Mechanical Engineers, 1852, pp. 99 and 153), the action of Centrifugal Pumps with *straight arms* was investigated, and it was shown that there is a waste of power to the extent of 50 per cent. in consequence of the circular motion communicated to the water. In Mr. Appold's pump this source of loss is avoided to a certain extent by *curving the blades*, and the experiments conducted by the Jury of the Great Exhibition show a saving of 44 per cent. over the same pump

with straight arms. But as the action of these blades has been supposed to be that of a system of inclined planes, (an idea in which the writer concurred at one time,) it appears desirable that the subject should be brought forward again for the purpose of investigating the true cause of the efficiency of curved blades.

Whilst therefore the present forms a supplement to the former paper, it will be found that the theory of curved arms constitutes the general proposition of which that of straight arms is the particular case, consequently it will be more convenient to consider the subject generally, referring only to the former paper for the explanation of those details which it would be useless to repeat.

A Centrifugal Pump, then, in its most general form, may be considered as a bent pipe A, see Figs. 3, and 4, Plate 40, revolving round a suction pipe B as a centre, the plane of revolution being either horizontal or vertical, and the curve being wholly in the plane of revolution, as it will be evident from the sequel that no good purpose would be served by the pipe having a double curvature.

In Fig. 1, Plate 40, let RPT be the centre line of the arm or pipe revolving round S in the direction of the arrow, the sectional area of the arm being uniform throughout.

ST the radius of the suction pipe $= R_1$,

SR the radius of the circle described by the extremity of the arm $= R_2$,

$\omega =$ the angular velocity,

$\theta =$ the angle PSX,

$r = f(\theta)$ the polar equation to the curve of the arm,

and $s =$ the length of the curve.

Let the sectional area of the pipe be constant and equal unity.

Then the weight of an elementary portion of the contained water is represented by its length;—which, taken with reference to the angle described by the radius vector, is $\dfrac{ds}{d\theta}$.

Since the element at P revolves in a circle of which the radius is SP, the centrifugal force is represented by*

$$\frac{\omega^2}{g}\,\mathrm{PS} \times \frac{ds}{d\theta} = \frac{\omega^2}{g}\, r\, \frac{ds}{d\theta}.$$

* Moseley's Mechanical Principles, Equation 108, page 125.

but by the principles of the differential calculus*

$$\frac{ds}{d\theta} = \sqrt{r^2 + \frac{dr^2}{d\theta^2}}.$$

Therefore the centrifugal force $= \frac{\alpha^2 r}{g} \sqrt{r^2 + \frac{dr^2}{d\theta^2}}$ ....(1.)

This force acts in the direction SP, and in order to ascertain its effect in propelling the water along the pipe it must be resolved into two others,—one in the direction of the tangent to the curve—the other at right angles to it.

If PS represent the amount of the centrifugal force, as well as its direction, PQ will represent the force expended on the material of the pipe, and PY that which urges the water above it.

The perpendicular on the tangent of a polar curve is represented by†

$$\frac{r^2}{\sqrt{r^2 + \frac{dr^2}{d\theta^2}}},$$

Hence $PY = \sqrt{SP^2 - SY^2} = \sqrt{r^2 - \frac{r^4}{r^2 + \frac{dr^2}{d\theta^2}}} = \frac{r\frac{dr}{d\theta}}{\sqrt{r^2 + \frac{dr^2}{d\theta^2}}}$

The Force along PY : Centrifugal force : : PY : PS,

or Force along PY : $\frac{\alpha^2 r}{g}\sqrt{r^2 + \frac{dr^2}{d\theta^2}} :: \frac{r\frac{dr}{d\theta}}{\sqrt{r^2 + \frac{dr^2}{d\theta^2}}} : r$

Therefore Force along PY $= \frac{\alpha^2 r}{g} \frac{dr}{d\theta}$ ....(2.)

Since the sectional area has been supposed equal throughout the length of the arm, the water must, in order to preserve its continuity, move with the same velocity at all points; therefore the whole force urging the water as one mass along the arm, is the sum of all the forces acting on the individual elementary portions.

Now the sum of all the forces represented by Equation (2) is the definite integral of that equation between the limits $r = R_2$ and $r = R_1$.

* Hall's Differential and Integral Calculus, page 172.
† Hall's Differential and Integral Calculus, page 171.

Therefore the whole force producing a flow through the arm

$$= \frac{a^2}{g}\int_{R_1}^{R_2} r\,\frac{dr}{d\theta} = \frac{a^2}{2g}\left(R_2^2 - R_1^2\right) \text{——————} (3.)$$

or it is precisely the same as if the arm were straight.

The effect of a varying section of a pipe will be discussed afterwards; but, supposing the section to be uniform, the water contained between two consecutive blades of Mr. Appold's Pump (see Fig. 6) is in exactly the same condition as that contained in this pipe. It must consequently be evident that until the force urging the water outwards be greater than the pressure of the working head (the height of the discharge above the surface of the water to be raised), no motion outwards can take place.

Whatever be the angular velocity, therefore, there is always a certain head which will be just supported and no more, and the cause of its being supported is centrifugal force.

If, then, whilst the velocity remains constant the head be diminished, a flow will take place: and there can be no reason for supposing the mode of action to change and become that of an inclined plane. It must, therefore, be admitted to be centrifugal action throughout, and the velocity through the arm is that due to the excess of the centrifugal force above the working head, and is equal to

$$\sqrt{2g\left\{\frac{a^2}{2g}\left(R_2^2 - R_1^2\right) - h\right\}} = \sqrt{a^2\left(R_2^2 - R_1^2\right) - 2gh}$$

Let $a\,R_2$ the velocity of the outer extremity of the arm be V_2

$a\,R_1$ ditto inner ditto ditto V_1

and let $2gh = v^2$

then the area of section being unity, the discharge per second is

$$\sqrt{V_2^2 - V_1^2 - v^2}.$$

The direction in which the water would move when it leaves the arm, would, if there were no circular motion, be that of the arm itself, or a tangent to the curve at the extremity.

Let SR, in Fig. 1, be the arm,

BRO a tangent to the curve of the arm at R;

Let BR represent the velocity of discharge,

and RD a tangent to the circle described by R represent the tangential velocity,

then RC is the actual motion in space in magnitude and direction.

$$RC^2 = RB^2 + BC^2 - 2\,RB\,.\,BC \cos.\ RBC$$

$$= \left(V_2^2 - V_1^2 - v^2\right) + V_2^2 - 2V_2\sqrt{V_2^2 - V_1^2 - v^2}\ \cos.\ \ RBC.$$

Let the angle SRO, which the radius vector makes with the tangent to the curve, be ϕ,

then the angle RBC $= \frac{\pi}{2} - \phi$, and $\cos.\ \left(\frac{\pi}{2} - \phi\right) = \sin.\ \phi$

Therefore $RC^2 = 2V_2^2 - V_1^2 - v^2 - 2V_2\sqrt{V_2^2 - V_1^2 - v^2}\ \sin.\ \phi$

Then the numbers of units of work expended upon communicating to the water the velocity with which it leaves the pump, is

$$U_1 = \frac{\left(2V_2^2 - V_1^2 - v^2 - 2\,V_2\sqrt{V_2^2 - V_1^2 - v^2}\ \sin.\ \phi\right)\sqrt{V_2^2 - V_1^2 - v^2}}{2\,g}$$

and the number of units of work expended on raising the water delivered to the height of discharge, is

$$U_2 = \frac{v^2}{2g}\sqrt{V_2^2 - V_1^2 - v^2}$$

Therefore the whole power

$$U_1 + U_2 = \frac{\left(2V_2^2 - V_1^2 - 2V_2\sqrt{V_2^2 - V_1^2 - v^2}\ \sin.\ \phi\right)\sqrt{V_2^2 - V_1^2 - v^2}}{2\,g} \quad \text{.........(4).}$$

$$\text{The useful effect} = \frac{v^2}{2g}\sqrt{V_2^2 - V_1^2 - v^2}$$

Therefore the ratio of useful effect to the power expended is

$$\frac{v^2}{2\,V_2^2 - V_1^2 - 2\,V_2\sqrt{V_2^2 - V_1^2 - v^2}\ \sin.\ \phi} \quad \text{...............(5)}$$

When $\phi = 0$, or the arm terminates in the direction of the radius, and if V_1 be considered so small that it may be neglected, the expression becomes

$$\frac{v^2}{2\,V_2^2}$$

which is the ratio given in the former paper for a pump with straight arms.

Equation (5) is evidently a maximum, or the duty is greatest, when $\sin.\ \phi$ is a maximum, or when $\phi = 90°$ the expression then becomes

$$\frac{v^2}{2\,V_2^2 - V_1^2 - 2\,V_2\sqrt{V_2^2 - V_1^2 - v^2}}$$

the value of which evidently increases as v diminishes, or the economy is greater the lower the lift.

It appears, then, that in order to get the greatest ratio of useful effect, the angle ϕ must be 90°,—that is, the arm must be bent back until the tangent at its extremity coincides with the tangent to the circle described by it. Hence the velocity of exit is directly opposed to the tangential velocity, and consequently the actual velocity of the water is the difference between the two velocities.

If $v = 0$, or there be no head, and the diameter of the suction pipe be so small that V_1 may be neglected, the velocity of discharge equals the tangential velocity, and the water drops off at rest.

We have here, then, an explanation of the economy arising from the use of *curved blades.* When the arms are straight the loss can never be less than one-half the power, because one-half is absorbed by the tangential velocity, and the only means of raising the per-centage of useful effect, is by *diminishing* the *velocity of discharge.* But with *curved arms* it is quite the reverse; the *greater the velocity* of discharge the less is the difference between it and the tangential velocity.

It is necessary to remark here, that in this inquiry it has been assumed that only that water which is between the blades has a rotatory motion, and that the centrifugal force, and consequently the column balanced by it, are less than if the blades extended completely to the centre. Now this is not exactly true, for it is evident that a certain amount of rotatory motion will be communicated to the water in the entrance by contact with the sides, and that part of the water which is revolving. The amount of this motion it is impossible to determine, but it will probably be proportionately greater the less the velocity through the pump.

The following table is calculated to show the variation of effect produced by a variation in height of lift—supposing the direction of the arm at the extremity to be a tangent to the circle described by it, V to be neglected, and the velocity of the extremity of the arm to be 32·2 feet per second—

HEIGHT OF LIFT.	PER-CENTAGE OF EFFECT, POWER BEING 100.
3 feet	93
6 „	90
9 „	83½
12 „	75
15 „	63
16 „	No delivery.

Although, as we have seen, the nature of the curve of the arm is a matter of no consequence as far as the principle is concerned, it must be more important in practice.

The form which would cause the water to move in a straight line from the centre to the circumference, would evidently be the best. This can be given only when there is no lift, that is when the velocity of delivery is equal to that of the end of the arm; but the curve which suits this case will give the nearest approximation at all other velocities of delivery.

Let PO, in Fig. 2, be a portion of the arm revolving round the centre S,—

let the velocity of flow through the arm be uniform and equal to c,—

α being the angular velocity of the pump,

$\alpha\, r$ is the actual velocity of the point P.

Then if PO bear the same proportion to PR (the portion of the circle described by P round S), that the velocity c does to the velocity of P;—the particle of water which at the commencement of the motion was at O, will reach P at the same instant that P reaches R,—that is, the particle at O will have moved through space along the line OR.

Let PY be a tangent to the curve of the arm,

the angle SPY $= \phi$

then PT $=$ PO sin. $\phi =$ PS sin. PST.

But the angle PST may be indefinitely diminished, and then the ratio of the line to the arc becomes one of equality; so that

PO sin. $\phi =$ PS $\delta\theta$, when $\delta\theta$ is the differential of the arc.

$$\text{Then make PO} : \text{PS}\,\delta\theta :: c : \alpha\, r$$

$$\text{or } \delta s : r\delta\theta :: c : \alpha\, r$$

$$\therefore \frac{\delta s}{\delta\theta} : \frac{ds}{d\theta} = \frac{c}{\alpha}$$

whence by integration $s = \frac{c}{\alpha}\,\theta$ .... (7).

$$\text{Therefore } \frac{ds}{d\theta} = \sqrt{r^2 + \frac{dr^2}{d\theta^2}} = \frac{c}{\alpha}$$

$$\text{whence } \frac{dr}{d\theta} = \sqrt{\frac{c^2}{\alpha^2} - r^2} \text{ and } \frac{d\theta}{dr} = \frac{1}{\sqrt{\frac{c^2}{\alpha^2} - r^2}}$$

$$\text{Therefore } \theta = \sin.^{-1} \frac{r\,\alpha}{c}$$

and $r = \frac{c}{\alpha}\,\sin.\,\theta$ .... (8)

which is the equation to the curve.

This differs from the spiral of Archimedes, as the equation to that curve is $r = m\,\theta$.

From equation (8) we have $\sin.\,\theta = \frac{\alpha\,r}{c}$ or $\theta = 90°$ when $c = \alpha\,r$, that is when the velocity of discharge is equal to the velocity of the arm.

In this case we find from (7) that $s = \frac{c}{\alpha}\,\frac{\pi}{2} = r\,\frac{\pi}{2}$ or the length of the arm is a quadrant of the circle described by the extremity.

Hitherto the sectional area of the arm has been supposed constant; —the next question for examination is what effect is produced by a variation of the section.

A *solid* of the form of the water contained in an arm of variable section, would have a centrifugal force dependent upon the position of the centre of the gravity;—but it is evident that the column which the centrifugal force of the *water* will balance, will be the same whether the section be uniform or variable, upon the same principle that the pressure per square inch produced by a vertical column is independent of any variation in the section of that column, and dependent only on its height.

It follows therefore that the column which is available for the production of the velocity of discharge, namely, the difference between the column representing the centrifugal force, and the height of the orifice of discharge above the surface of the water in the cistern, is the same, whether the section of the arm be constant or variable.

If the section diminishes towards the outer extremity, the velocity will increase; if the section increases, the velocity will diminish. But as the velocity produced by a given column can only be that due to the height of the column, it must in the first instance be considered as divided into two parts,—one producing the velocity with which the water must be added at the entrance of the pipe, the other producing the acceleration;—in the latter case the water is dragged through the entrance with a velocity greater than the ultimate velocity, and loses it in its passage through the pipe by communicating in its turn excessive velocity to the water entering. There appears therefore to be no advantage in principle in giving to the arm a variable section.

In corroboration of this view of the subject, the experiments of Venturi may be appealed to. It is well known that when a conical pipe, as A B in Fig. 5, was attached to an orifice in a vessel kept constantly full, the discharge was due to the head of water above the centre of the pipe and the area of the orifice B. But when a diverging conical pipe B C was added, the discharge was considerably increased. This increase of delivery has been attributed to the attraction of the sides of the pipe for the water, but this is a cause wholly inadequate to the effect. It is clear that whatever be the velocity of a particle at B, it is diminished when it comes to C in the same proportion as the sectional area is increased. But no effect can be produced without a cause: some retarding force must therefore have been in operation.

Suppose the velocity to continue the same;—the portion of water at B, (section-lined) becomes thinner as it advances along the expanding pipe to C, and according to the supposition, the continuity of the water will be broken, and a space left between all the elementary portions into which the water may be supposed to be divided. But the space so left (shown white) would be a vacuum, and consequently the pressure of the atmosphere would be exerted to propel the particles at B faster, and check the velocity of those in advance.

It must therefore be evident that the effect will be that the continuity of the water is preserved, and the motion of the particles at B increased considerably beyond what it would otherwise have been.

For the production of this effect it is necessary that the pipe be of such a material that there may at least be no repulsion between it and the water, as in that case the water would not flow in a full stream;—and it must moreover be evident that if it were not for friction, the velocity of discharge at C would be precisely the same as if the orifice B had had the same size, and there had been no additional conical pipe. In practice friction has a considerable influence, and the delivery is accordingly less than that due to the head and the area at C.

From Equation (6) it appears that, *ceteris paribus*, the economy is greater the smaller V is; that is, the smaller the diameter of the suction pipe. But if this pipe were made very small, power would be lost in communicating to the water an unnecessary velocity, and therefore it follows that the most advantageous proportion is when the area of the suction pipe at the entrance of the arm is just equal to that of the arm, and that the per-centage realized with one arm will be greater than when there are several. It also follows that it is more advantageous to increase the diameter of the pump than the angular velocity.

In Mr. Appold's Pump the diameter of the suction pipe bears a large proportion to the diameter of the disc, being as much as one half. It will likewise be evident from the drawing, Fig. 6, of this pump, that the channel formed by two contiguous blades A A, does not terminate at R in the direction of a tangent to the circle described by the extremity, but makes a considerable angle with the tangent. It may therefore be expected that a higher per-centage may yet be realized than is shown by the experiments of the Jury of the Great Exhibition.

IMPROVED RAILWAY CHAIR.

Fig. 1. *Joint Chair. Inner side.*

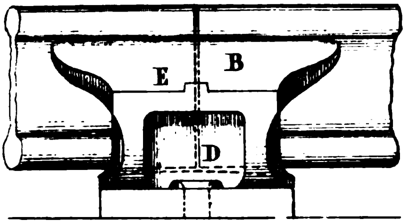


Fig 2. *Joint Chair. Outer side.*

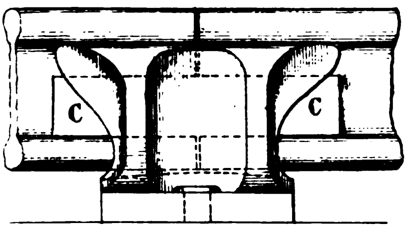


Fig. 3. *Joint Chair. Plan*

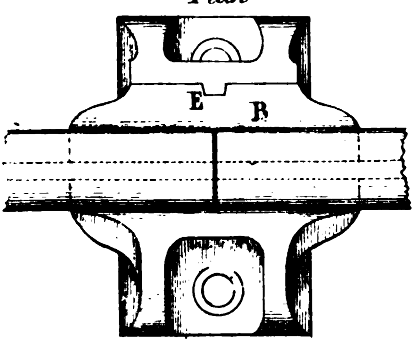


Fig 4. *Intermediate Chair.*

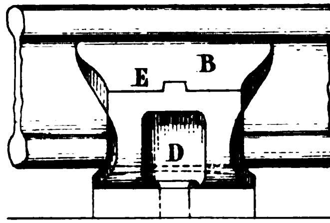


Fig. 5. *End View.*

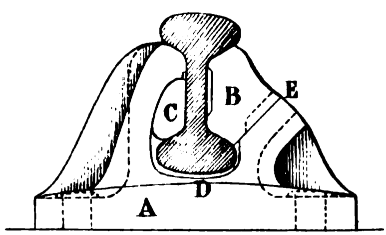


Fig. 6. *Chair with Iron Key.*

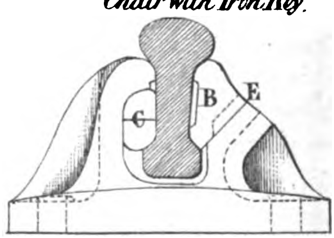


Fig 7. *Iron Key to Fig 6.*

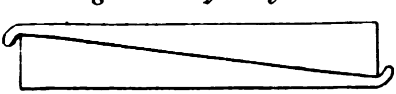
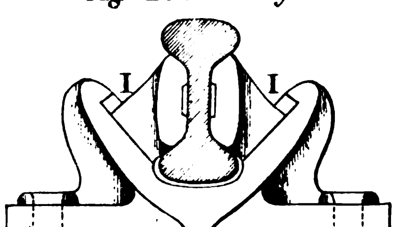


Fig 8. *Double-Wedge Chair.*



Scale 1/6th. 0 3 6 9 12 *Inches*

IMPROVED RAILWAY CHAIR.

Experiments on the Strength of Chairs.

Fig. 9. *Intermediate Chair.*

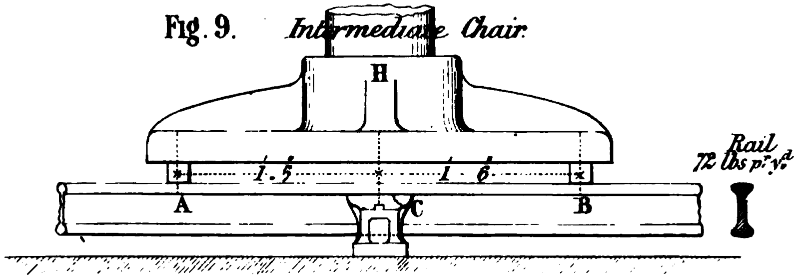


Fig. 10. *Joint and Intermediate Chairs.*

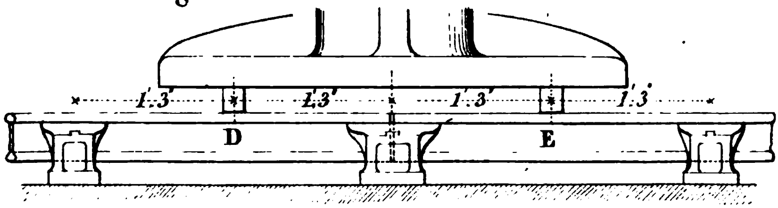
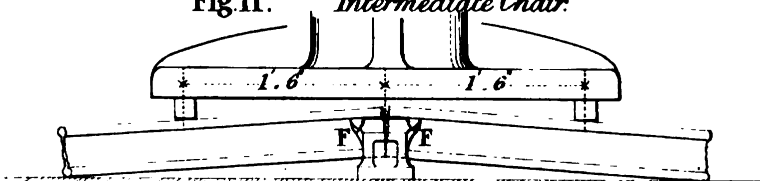
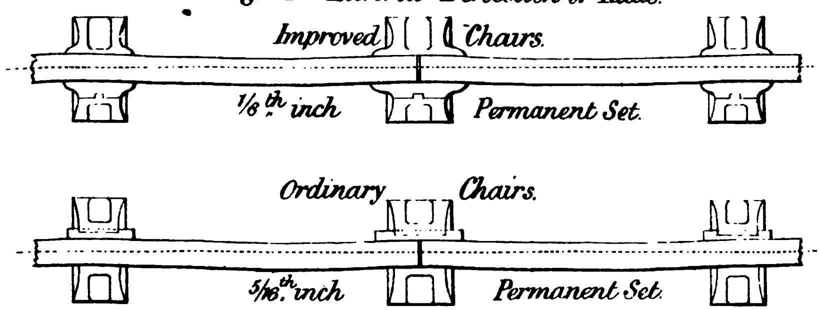


Fig. 11. *Intermediate Chair.*



Rail broken at 60 Tons pressure.

Fig. 12. *Lateral Deflection of Rails.*



Scale 1/18th

IMPROVED RAILWAY CHAIR

Permanent Way,
with Longitudinal Sleepers under the Joints.

Fig. 13. *Side Elevation.*

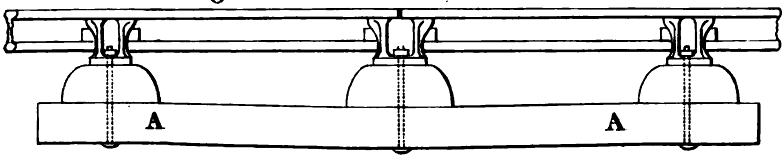
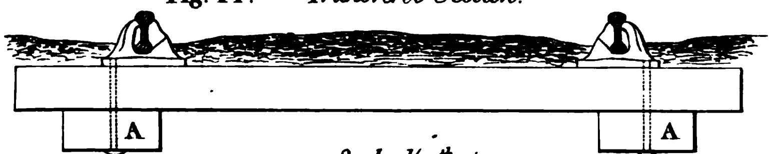


Fig. 14. *Transverse Section.*

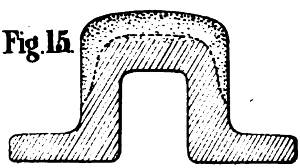


Scale 1/24th size

IRON MANUFACTURE

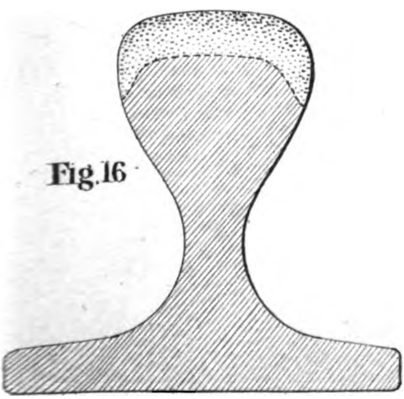
Rails with Hardened Iron Tops.

Fig. 15.



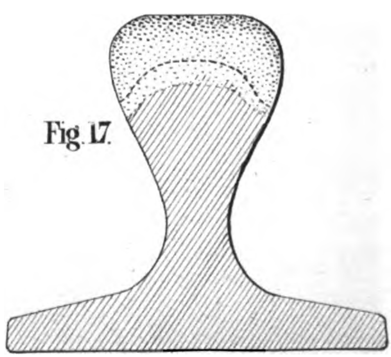
Hardened Scotch Iron.

Fig. 16.



Consett.

Fig. 17.



Cyfarthfa.

Scale ½ size.

Experiments on the Transverse Strength of Cast Iron Girders.

1st Ordinary Cast Iron.

Fig. 1. *34 Tons Breaking strain.*

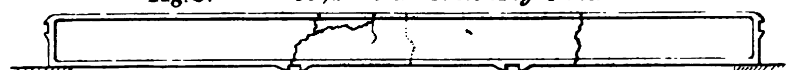
Calder, Scotch Hot-Blast No 1.

Fig. 2. *33¼ Tons Breaking strain.*

Russell's Hall Hot-Blast No 2.

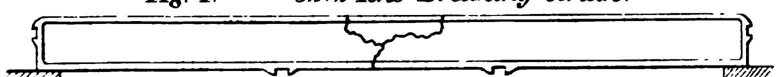
2nd Toughened Cast Iron

Fig. 3. *60½ Tons Breaking strain.*



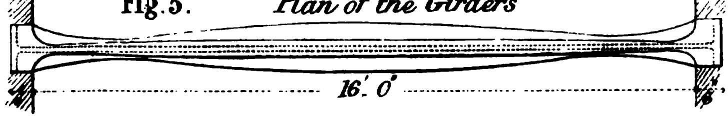
Calder, Scotch Hot-Blast	*80 per cent.*
Wrought Scrap	*20 do.*

Fig. 4. *52½ Tons Breaking strain.*



Russell's Hall Hot-Blast	*38 per cent.*
Prior Field Hot Blast	*48 do.*
Wrought Scrap	*14 do.*

Fig. 5. *Plan of the Girders*



Scale 1/54th size

Fig. 6. *Transverse Section of Girders*

Double Scale

CUGNOT'S LOCOMOTIVE ENGINE, 1769.

Fig 1. *Elevation.*

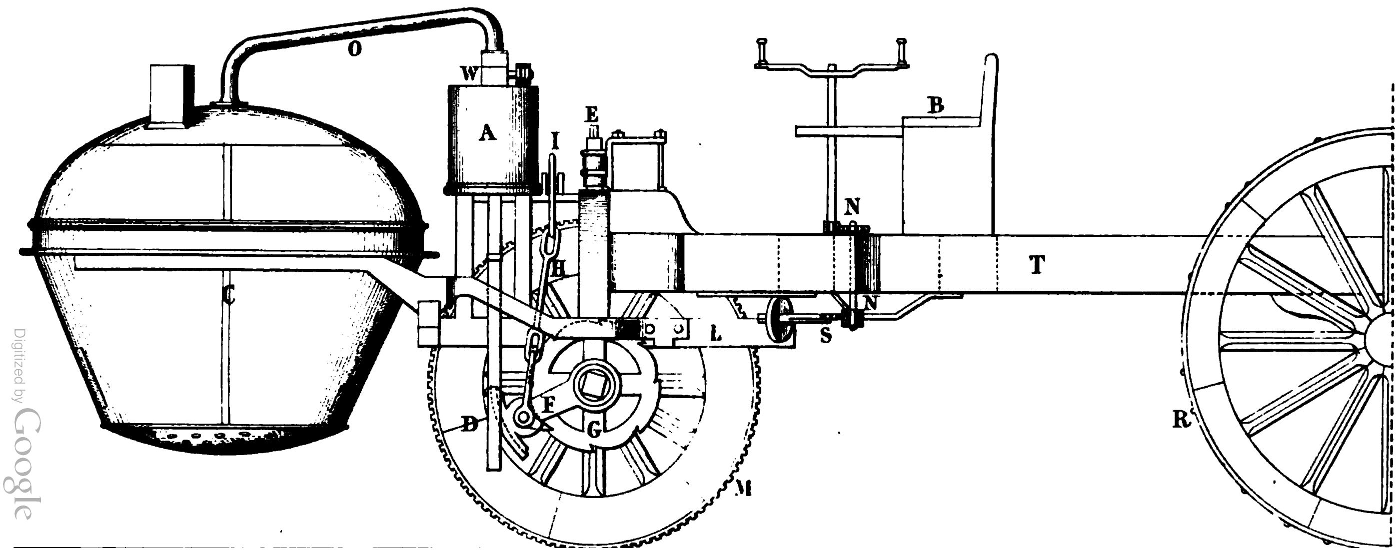
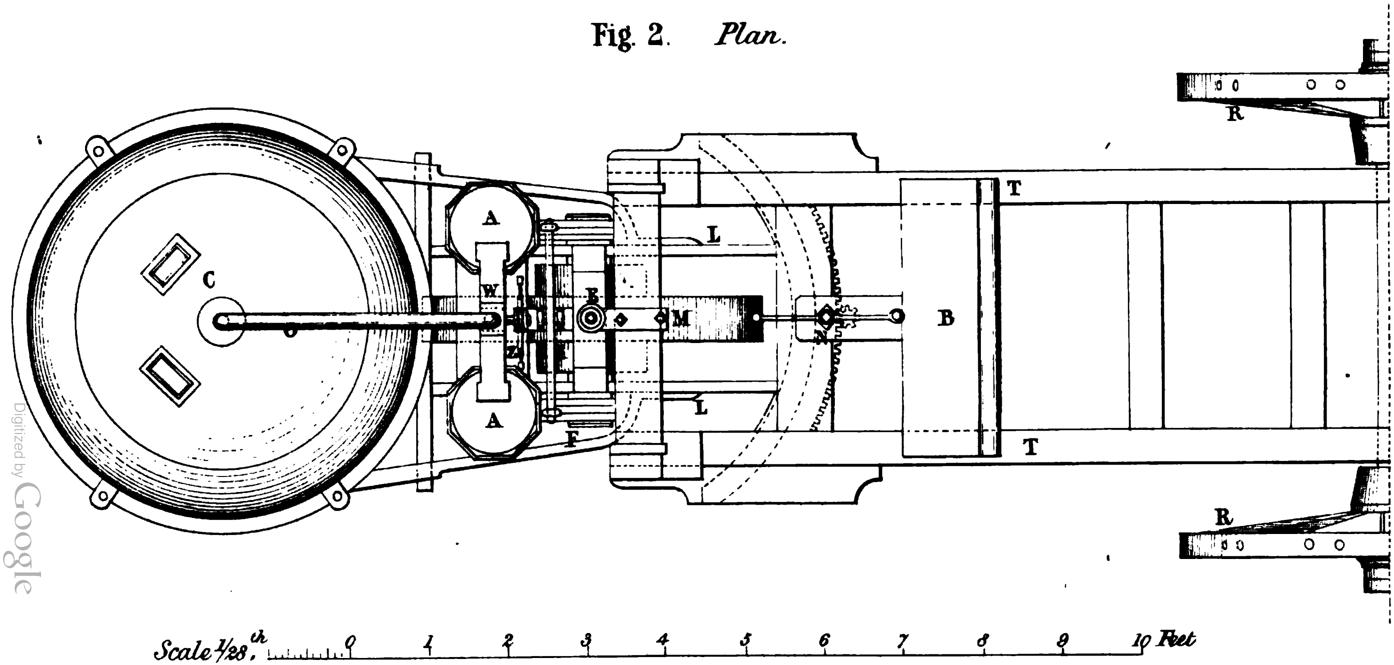


Plate 6.

CUGNOT'S LOCOMOTIVE ENGINE, 1769.

Fig. 2. *Plan.*



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CUGNOT'S LOCOMOTIVE ENGINE, 1769.

Fig. 3. *Longitudinal Section.*

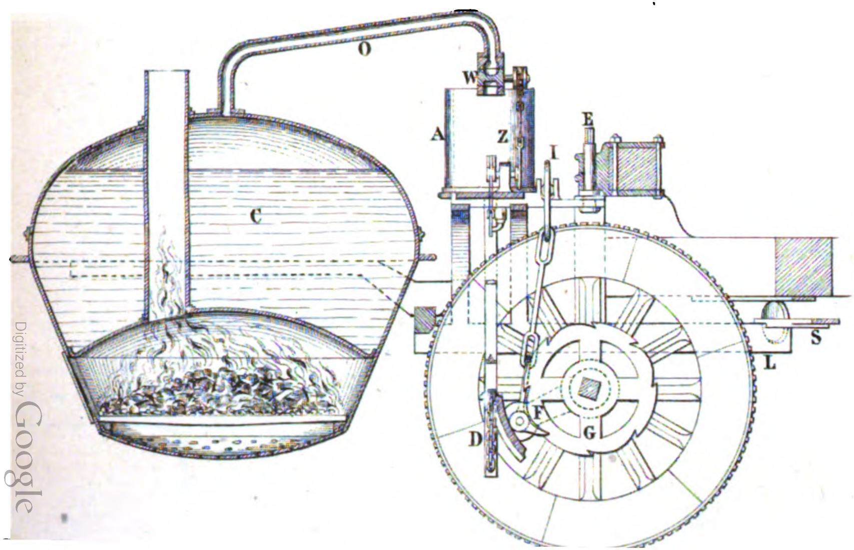
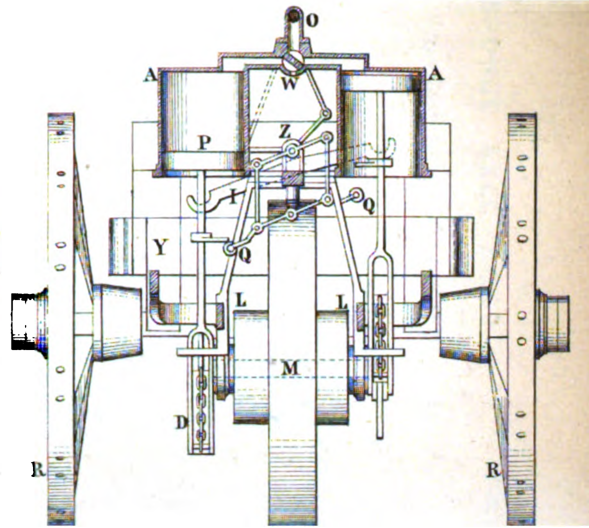


Fig. 4. *Transverse Section.*



SPONGE AXLE-BOX.

Engine Axle-Box for Leading & Trailing Wheels.

Fig 1.
Longitudinal Section

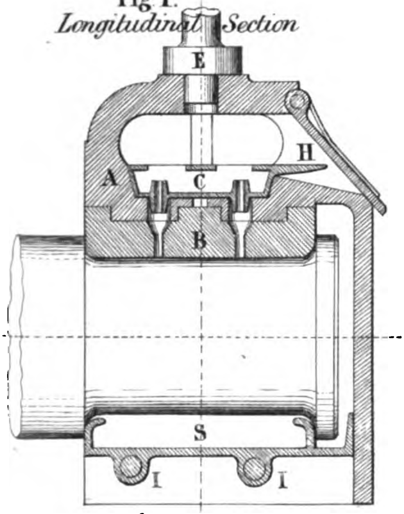
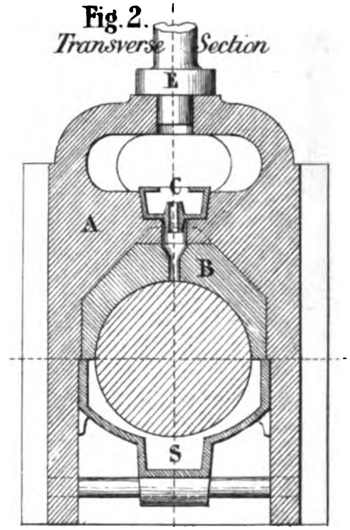


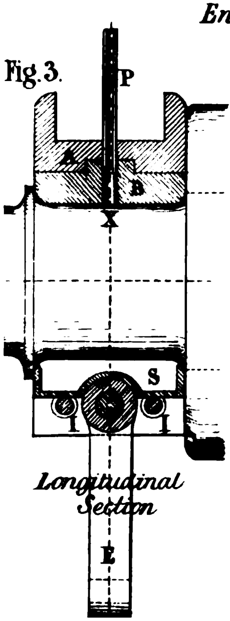
Fig. 2.
Transverse Section



Scale 1/5th 0 3 6 9 12 Inches

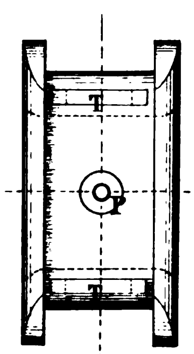
Engine Axle-Box for Driving Wheels.

Fig. 3.



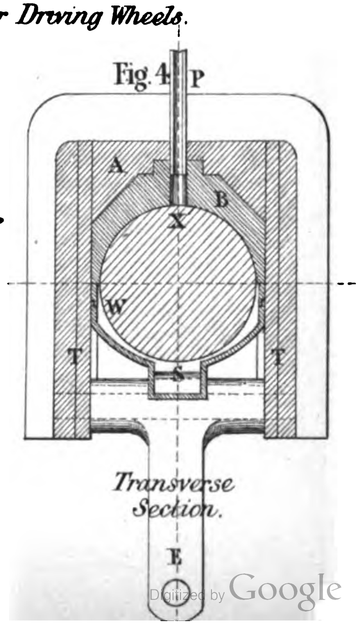
Longitudinal Section

Fig 5.



Plan

Fig. 4.

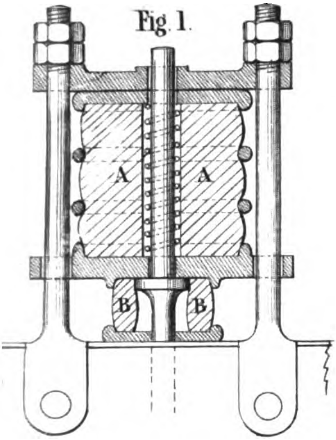


Transverse Section.

INDIA-RUBBER SPRINGS.

Engine Bearing Spring

Fig. 1.



Triple Bearing Spring.

Fig. 2.

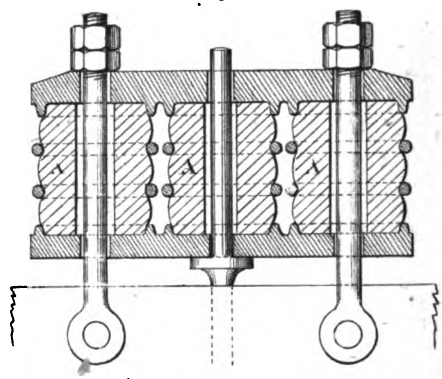


Fig. 3. *Waggon Bearing Spring*

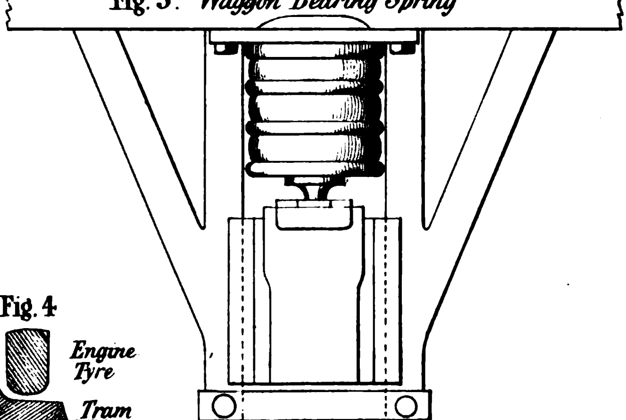


Fig. 4

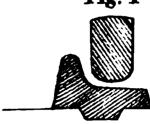


Fig. 5.
Engine Draw Spring

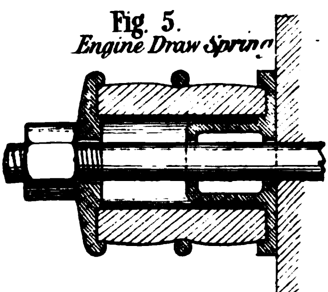
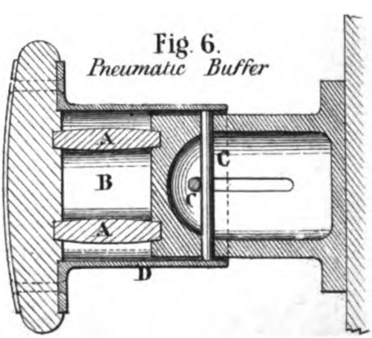


Fig. 6.
Pneumatic Buffer



Scale 1/10th 0 6 12 18 24 Inches

INDIA RUBBER SPRINGS.

Plate 10.

Fig. 7. *Hydro-Pneumatic Engine Spring.*

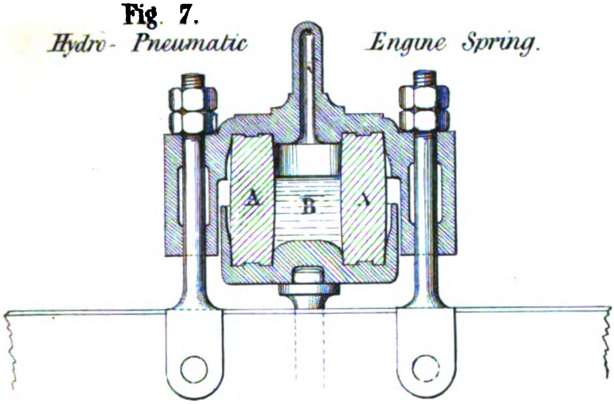


Fig. 8. *Improved Hydro-Pneumatic Spring*

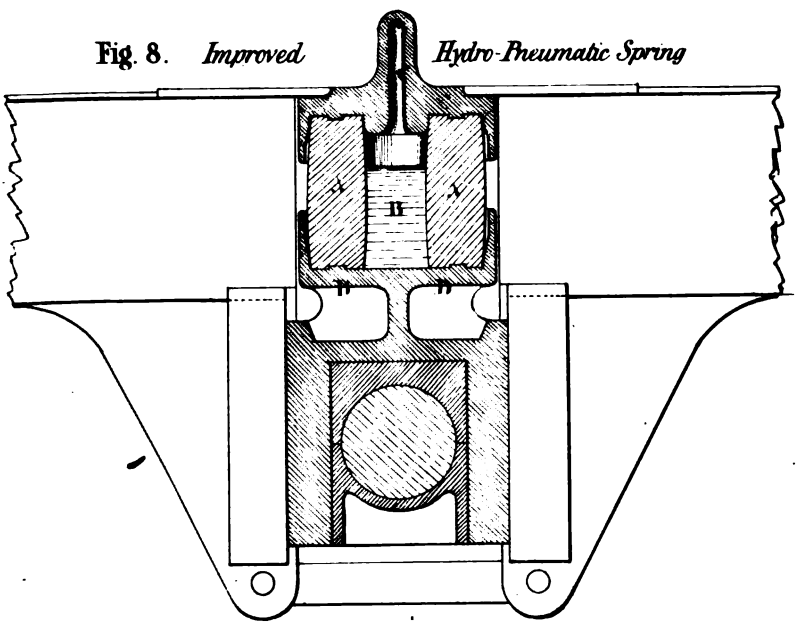
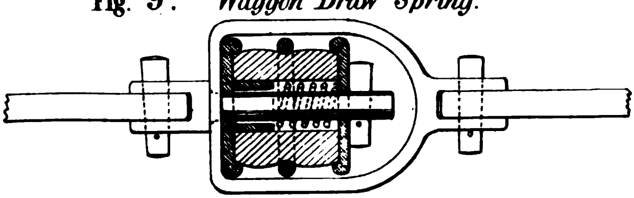


Fig. 9. *Waggon Draw Spring.*



Scale 1/10th. 0 6 12 18 24 Inches

(Proceedings Inst. M.E. 1853. Page 48.)

Fig. 1.

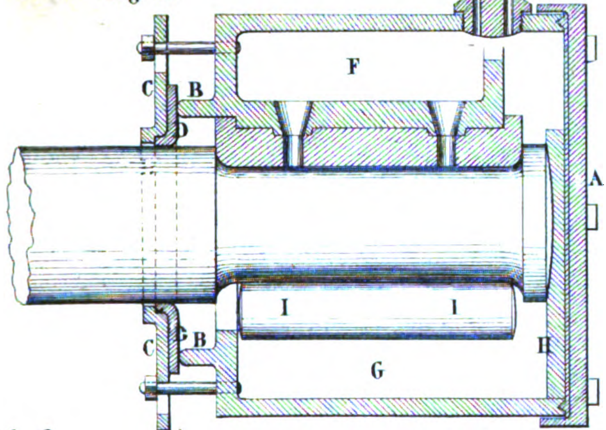


Fig. 2.

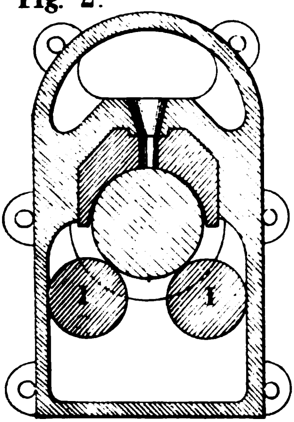


Fig. 4.

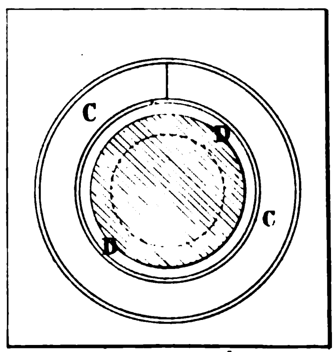
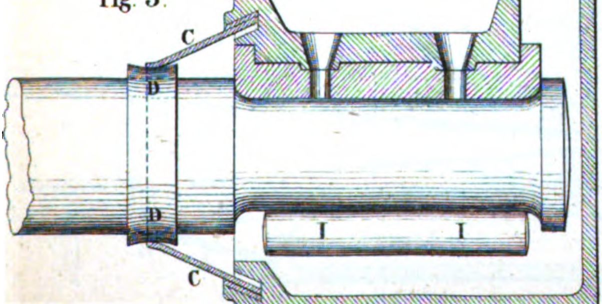


Fig. 3.



Scale 1/5th. 0 3 6 9 12 Inches

(Proceedings, Inst. M. E. 1853. Page 60)

ADAMS' CARRIAGE AXLE-BOX.

Fig. 5.

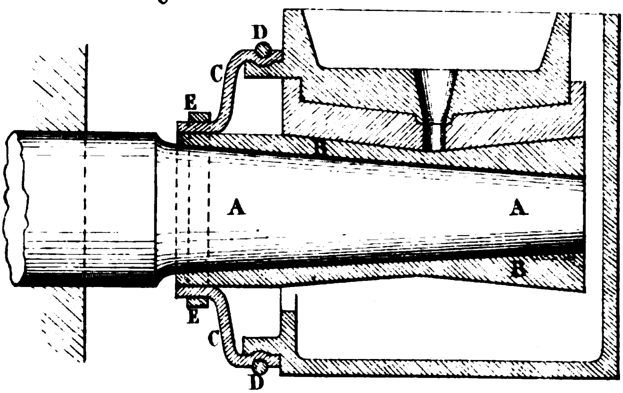


Fig. 6.

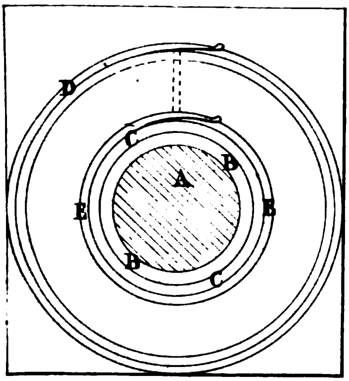


Fig. 8.

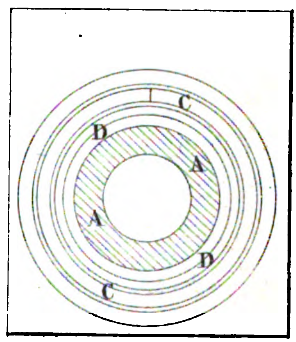
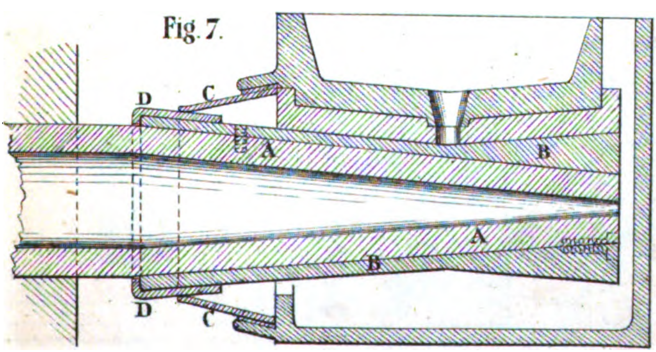


Fig. 7.



Scale 1/5th 0 3 6 9 12 Inches

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PORTABLE STEAM ENGINE. Plate 13.

Fig. 1. Side Elevation

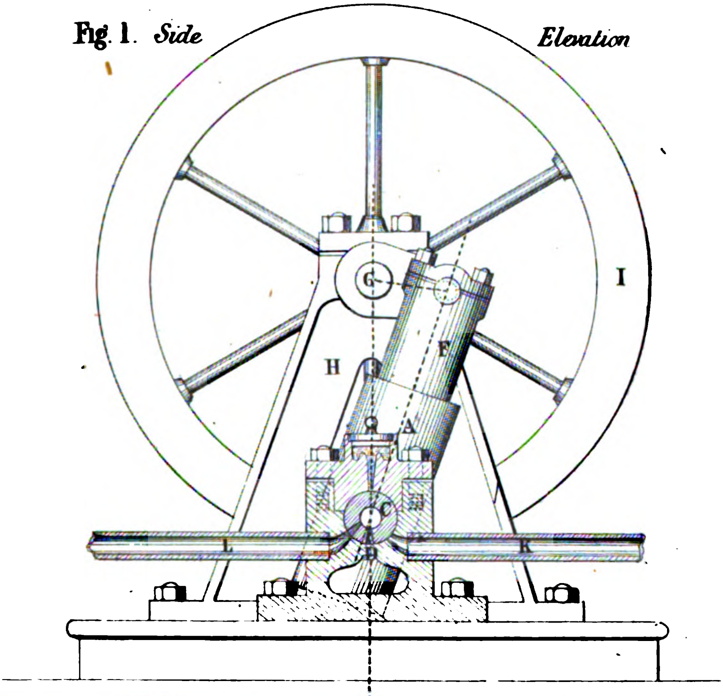


Fig. 2. Section of Cylinder

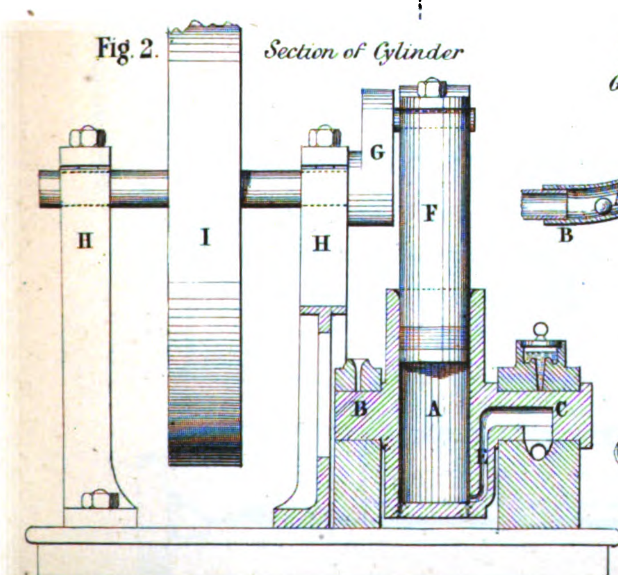
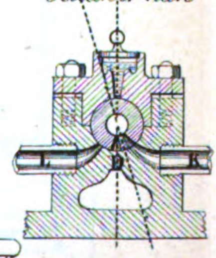


Fig. 3. Governor

Fig. 4. Section of Valve



Scale 1/8th. 12 Ins. 9 6 3 0 1 Feet

(Proceedings Inst. M.E. 1853, Page 69)

PORTABLE STEAM ENGINE.

Fig 5

Elevation of Engine and Boiler.

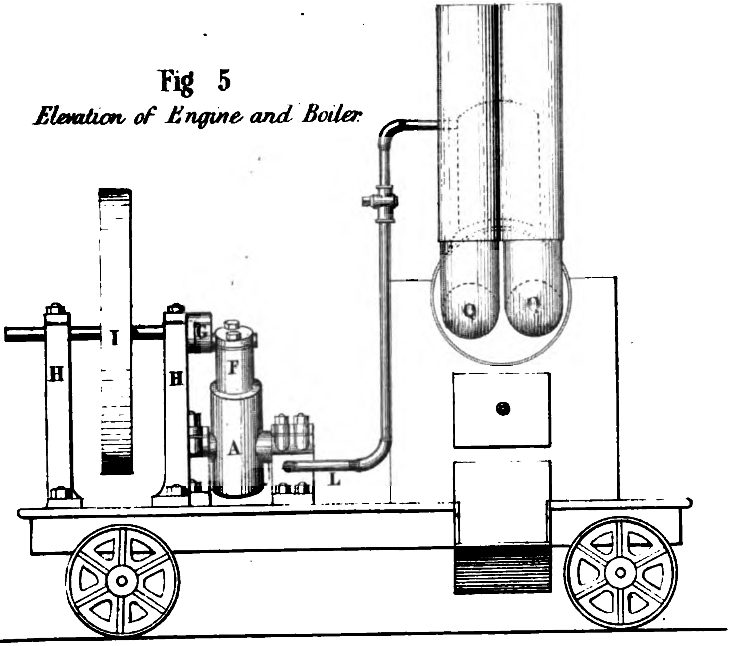
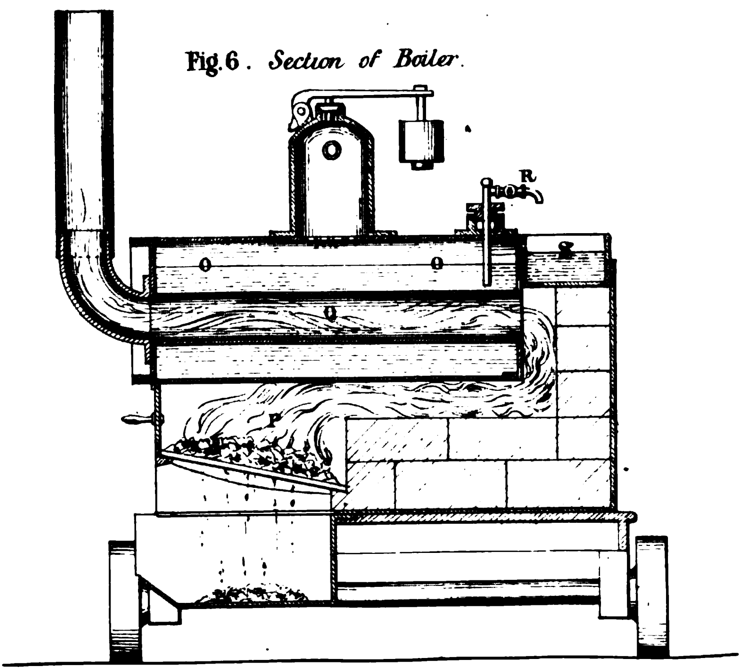


Fig. 6. *Section of Boiler.*



Scale 1/16" 0 1 2 3 Feet

STEAM ENGINE GOVERNORS. *Plate 15.*

Fig. 1. *Watt's Centrifugal Governor*

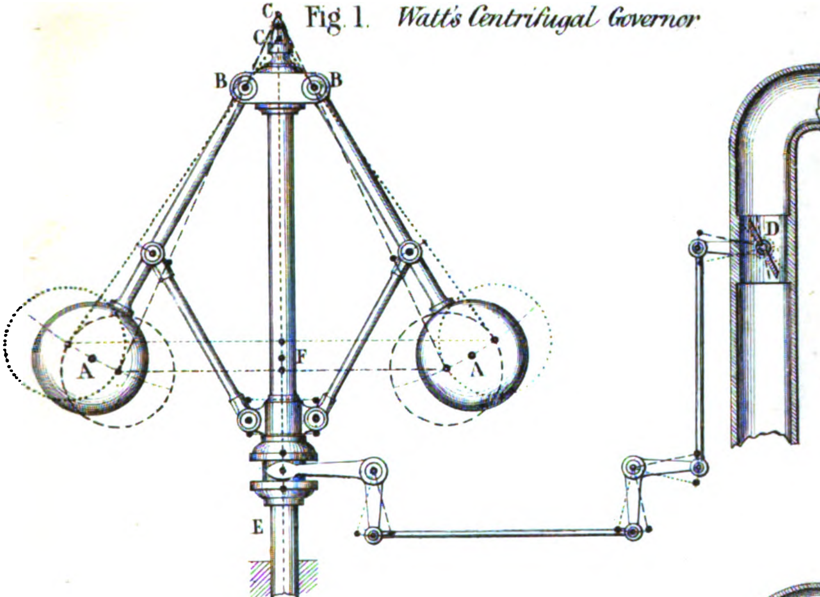
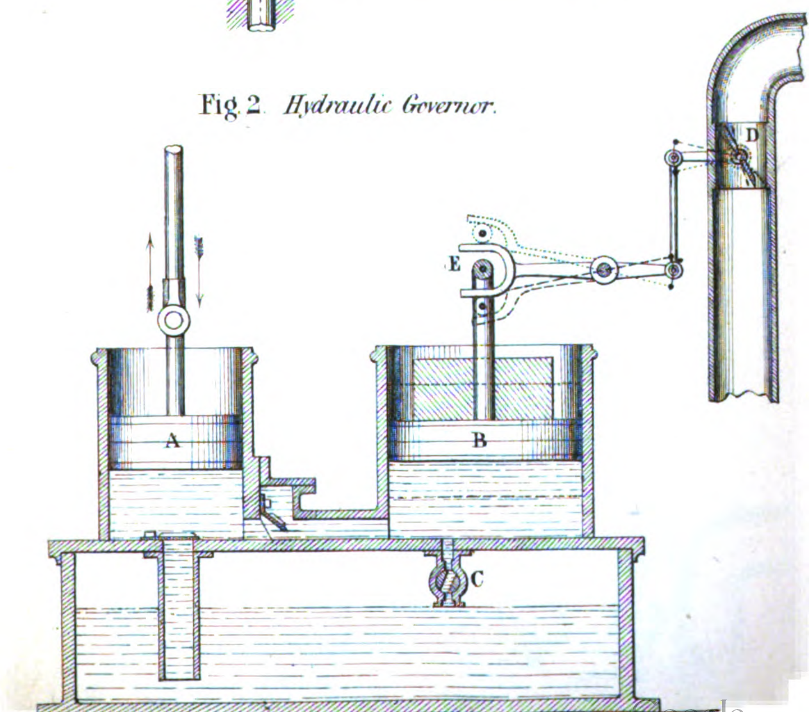


Fig. 2. *Hydraulic Governor.*



Scale Linch 0 1 2 *Feet*

Hick's Fly Governor.

Fig. 3.

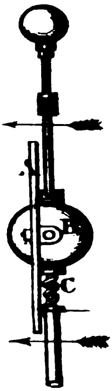
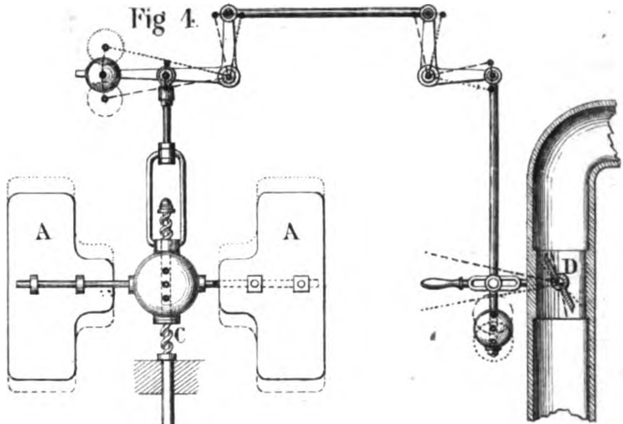


Fig 4.



Hick's Fly Governor. 2nd form

Fig. 5.

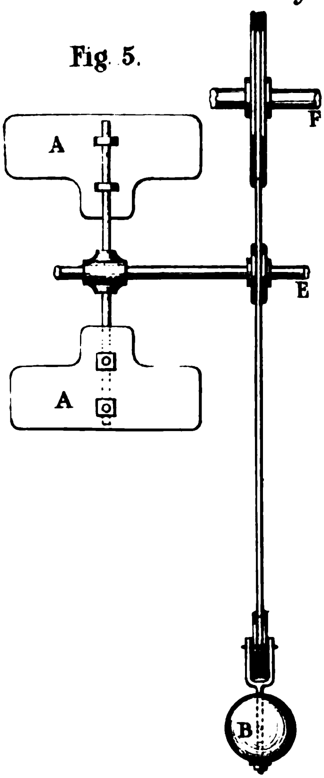
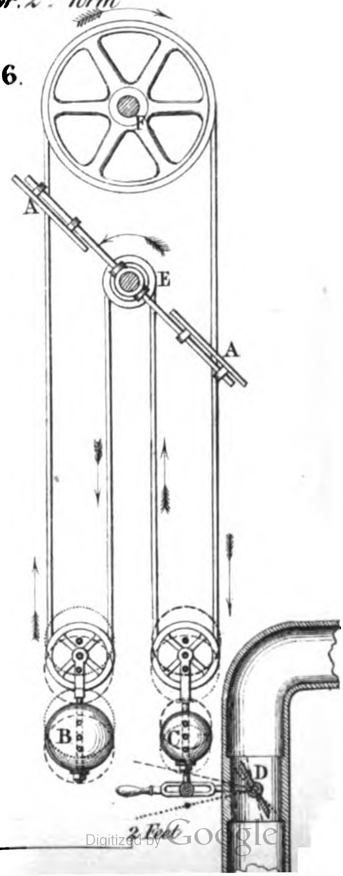


Fig. 6.



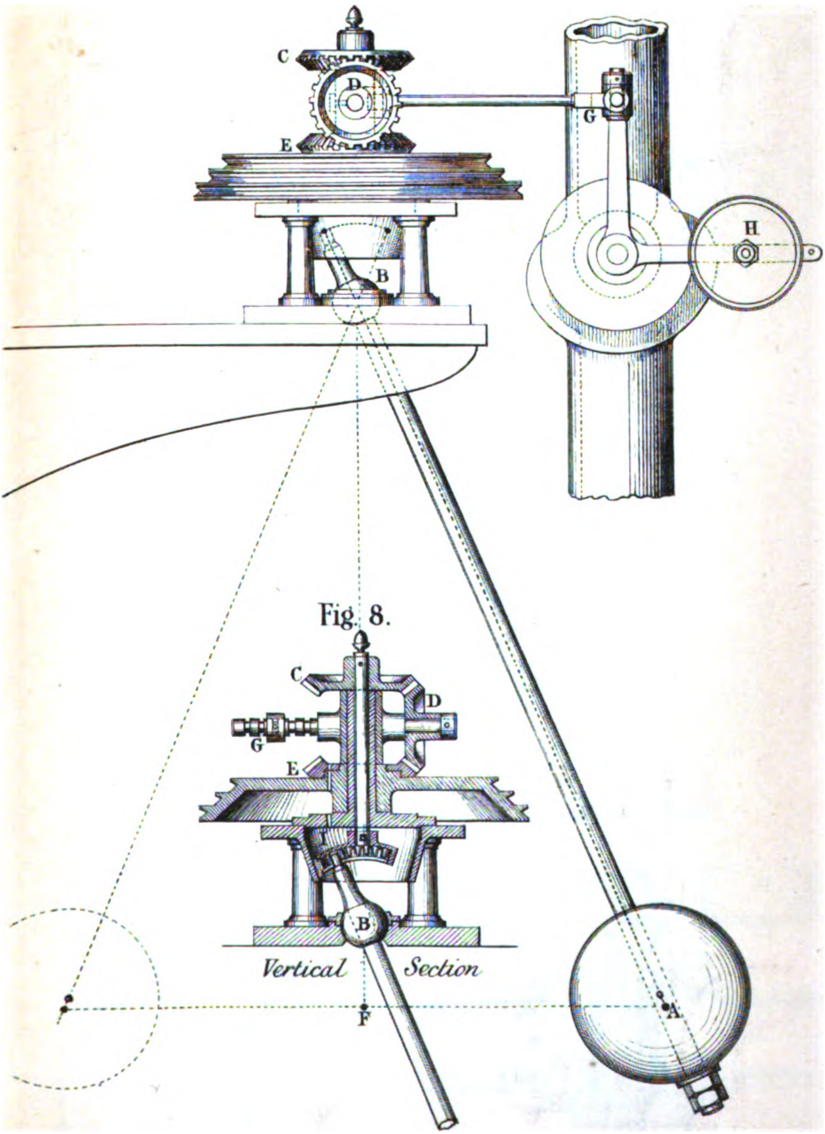
Scale 1/16th 0 1 2 Feet

(Proceedings Inst. M.E. 1853 Page 77)

STEAM ENGINE GOVERNORS.

Siemen's Original Chronometric Governor.

Fig. 7. *Elevation*



Scale 1/10th 12 9 6 3 0 1 Foot

STEAM ENGINE GOVERNORS.

Siemen's Improved Chronometric Governor.

Fig. 9. *Vertical Section.*

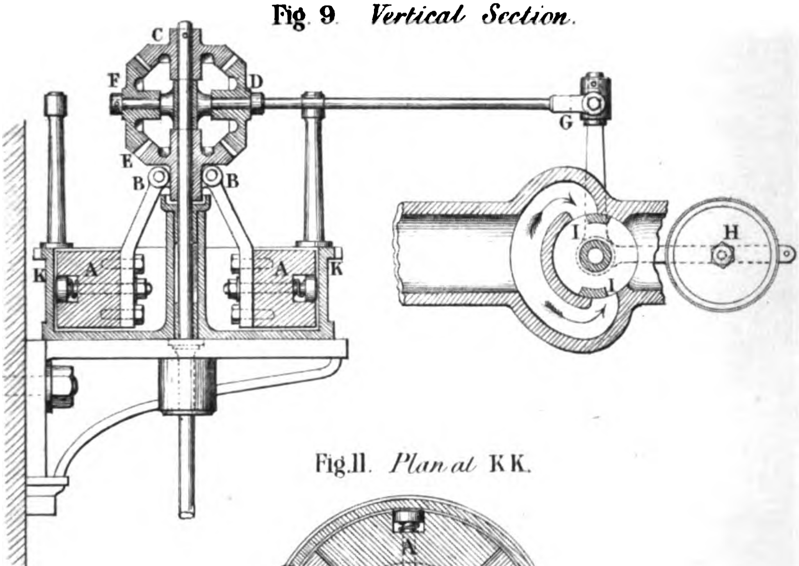


Fig. 11. *Plan at* K K.

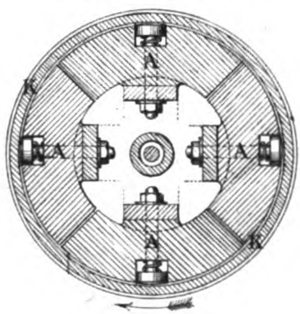


Fig. 10. *Plan with section of Valve*

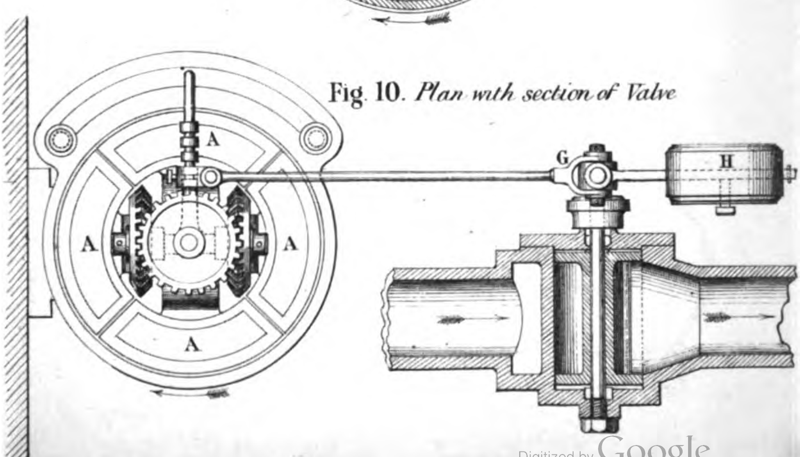


Fig. 1.
Section of Rolls.

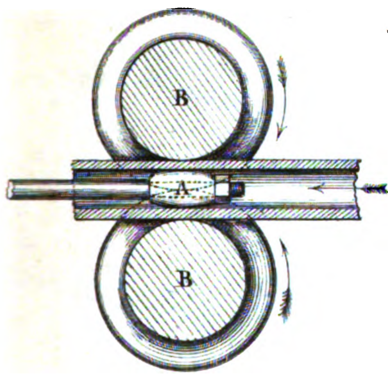


Fig. 2.
Elevation of Rolls.

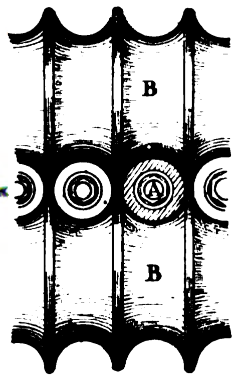
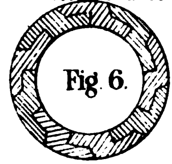


Fig. 5.
Section of Bar.

Section of Pile



Section of Axle

Fig. 3. *Longitudinal Section of Axle, rolled & welded.*

Fig. 4. *Longitudinal Section of Axle, with journals formed.*

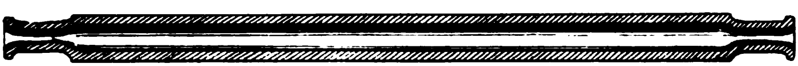


Fig. 8. *Section of Finished Axle, with Parallel Journals.*

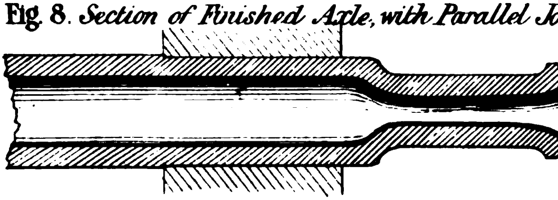
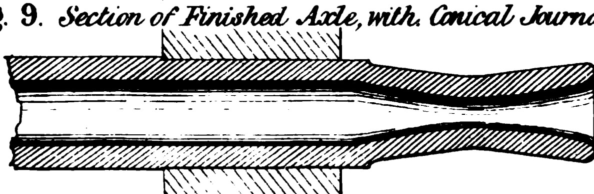
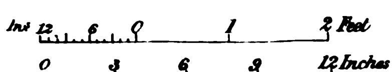


Fig. 9. *Section of Finished Axle, with Conical Journals.*



Scale 1/20th Figs 1 to 4

Scale 1/8th Figs 5 to 9



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HOLLOW RAILWAY AXLES.

Experiments on Hollow and Solid Axles

Fig. 10. *Fracture of Solid Axle*

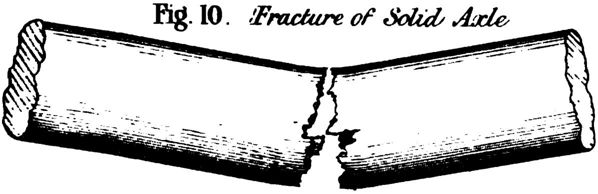


Fig. 11. *Section of fracture.*

Fig. 12. *Fracture of Hollow Axle*

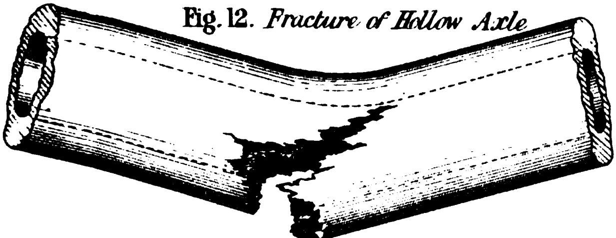


Fig. 13. *Section of fracture.*

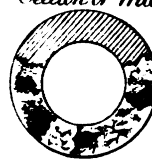


Fig. 14. *Journal of Solid Axle*

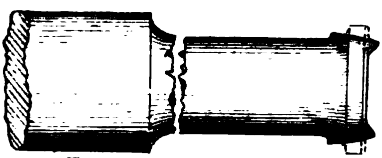


Fig. 15. *Face of fracture*

Fig. 16. *Journal of Hollow Axle.*

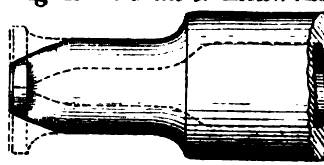
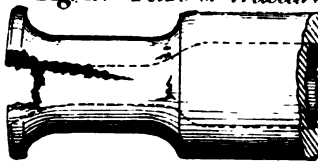


Fig. 17. *Plan of fracture.*



Gauge for thickness of Hollow Axles.

Fig. 18. *Side Elevation*

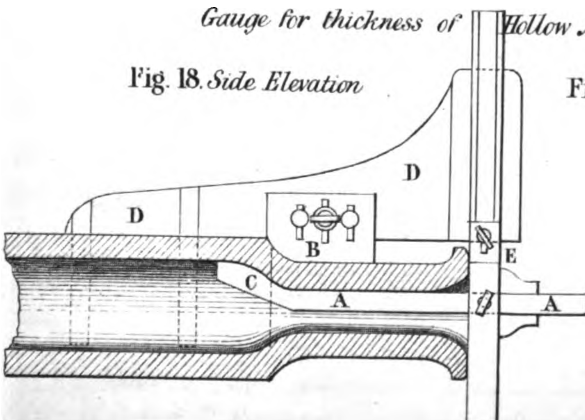
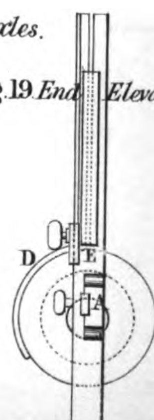


Fig. 19. *End Elevation*



Scale 1/6th. 0 3 6 9 12 Inches

IMPROVED JOINT CHAIR.

Fig. 1.

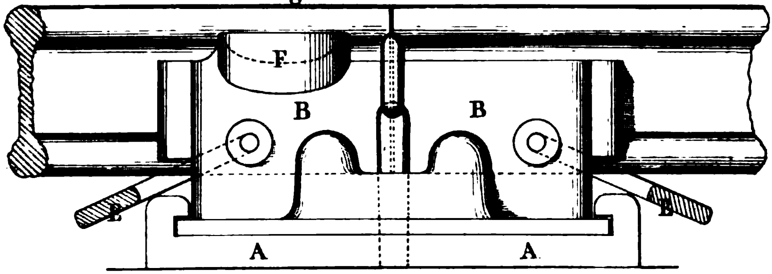


Fig. 2.

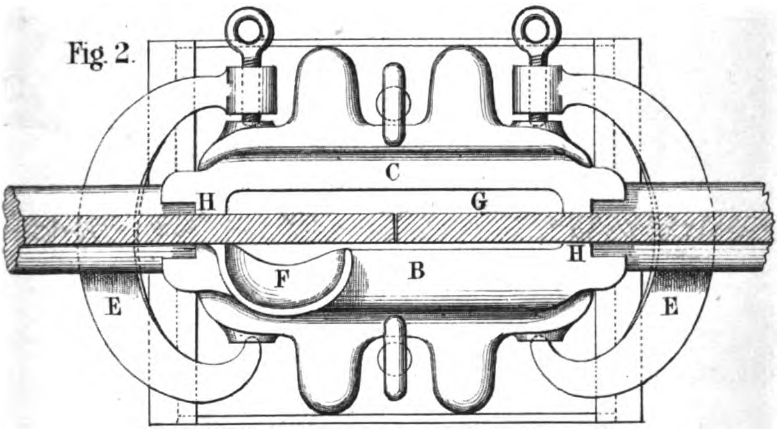


Fig. 3.

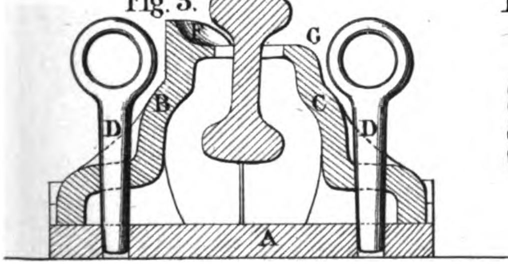


Fig 6.

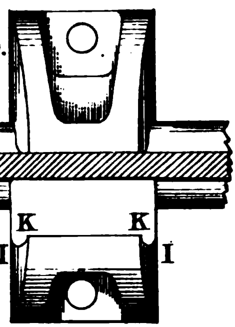


Fig. 4.

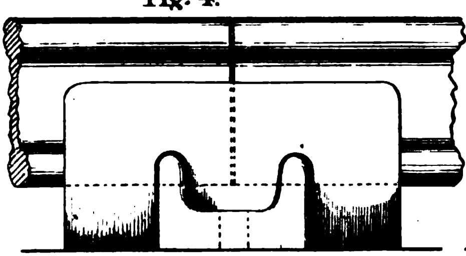
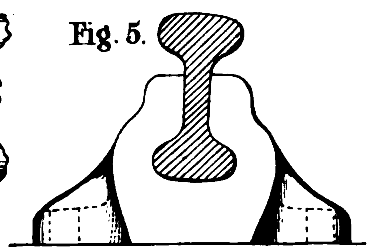


Fig. 5.



Scale 1/8th 0 3 6 9 12 Inches

(Proceedings Inst. M.E. 1853, Page 102.)


E
E

Portable Cupola & Fan

Fig. 7. *Elevation.*

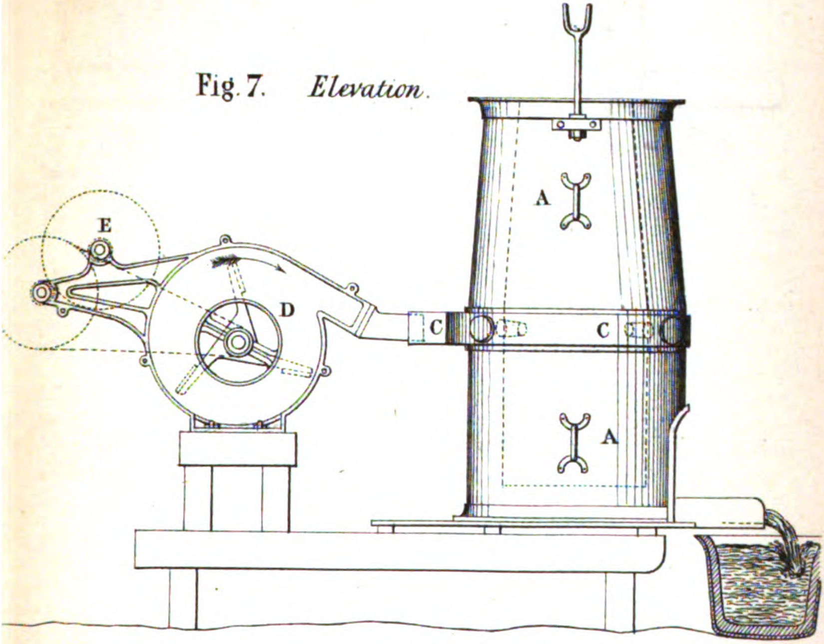
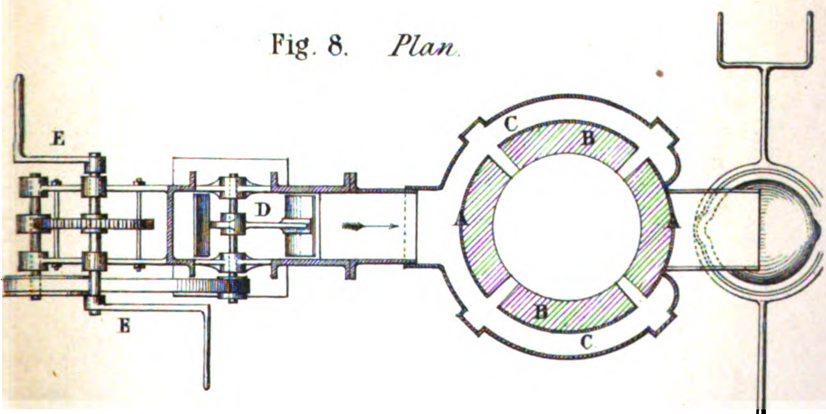
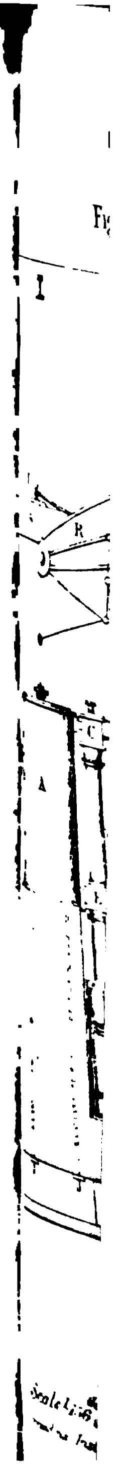


Fig. 8. *Plan.*

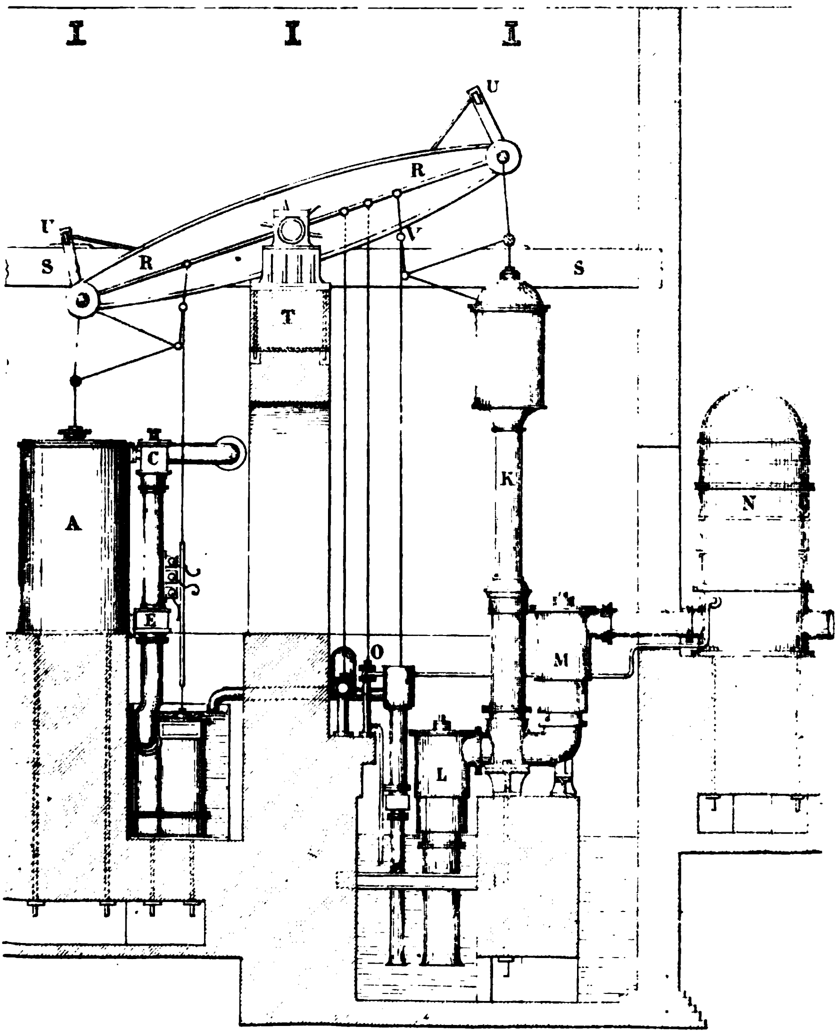


Scale 1/24th 0 1 2 3 4 5 Feet


R
A

PUMPING ENGINE,
BIRMINGHAM WATER WORKS.

Fig. 1. *Elevation of Engine and Pump*



Scale 1/256th 0 5 10 15 20 25 30 35 40 Feet

(Proceedings Inst. M.E. 1853, Page 110.)

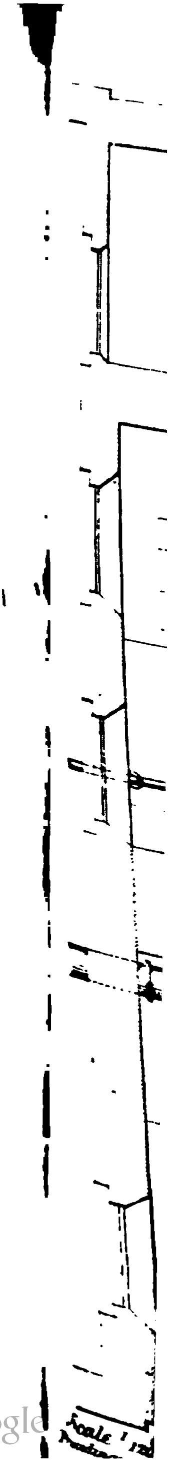
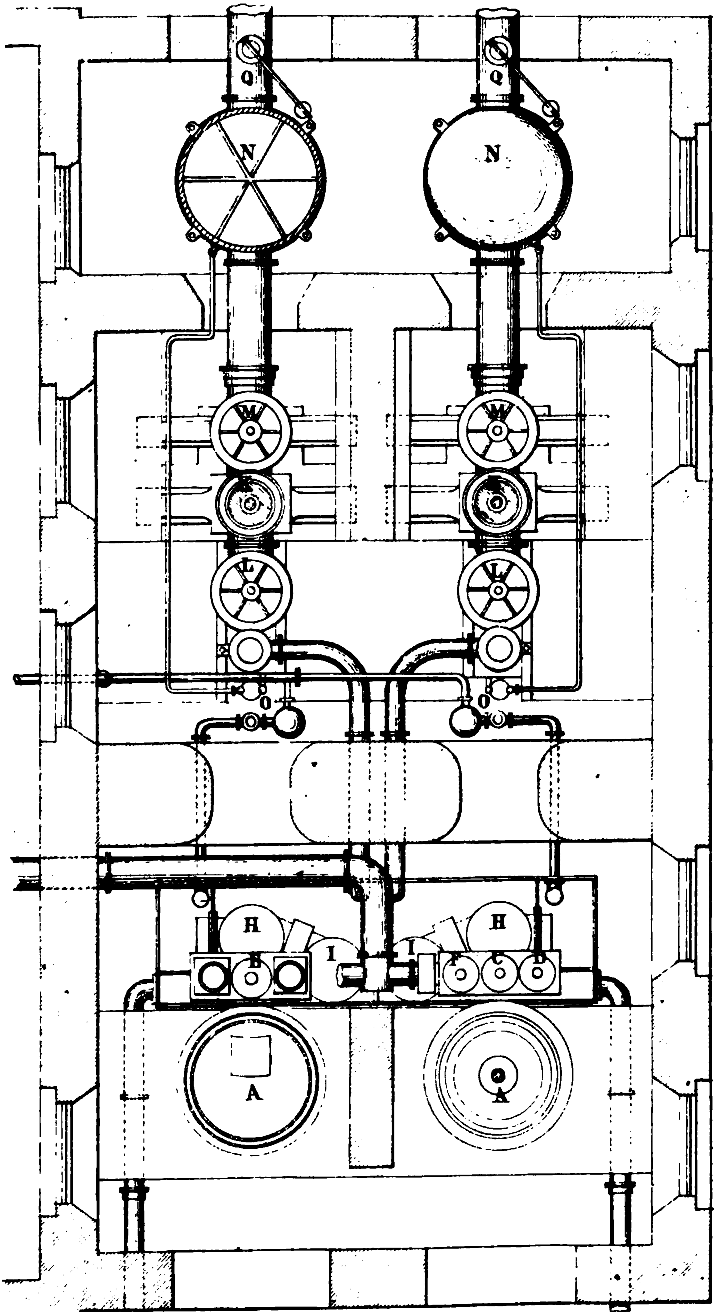


Fig. 4. *Plan*

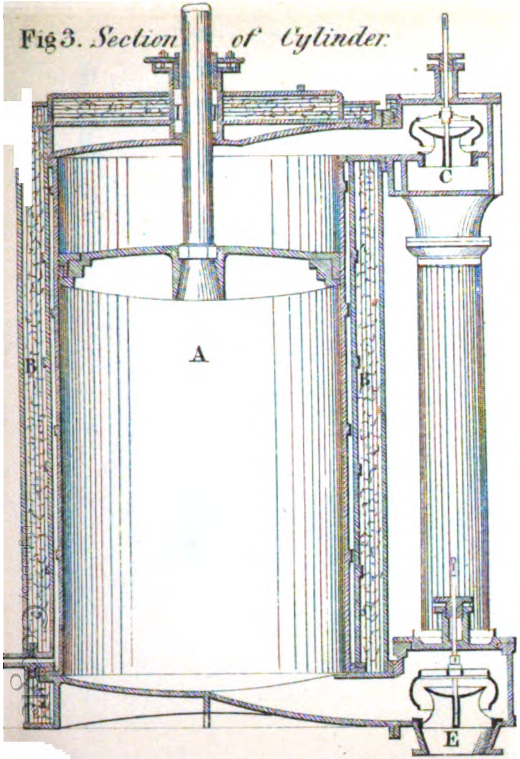


Scale 1/120th 0 5 10 15 20 25 30 Feet

(Proceedings Inst. M.E. 1853, Page 110)

PUMPING ENGINE. Plate 25

Fig 3. Section of Cylinder.



Scale 1/48th

Fig 4. Section through Nozzles

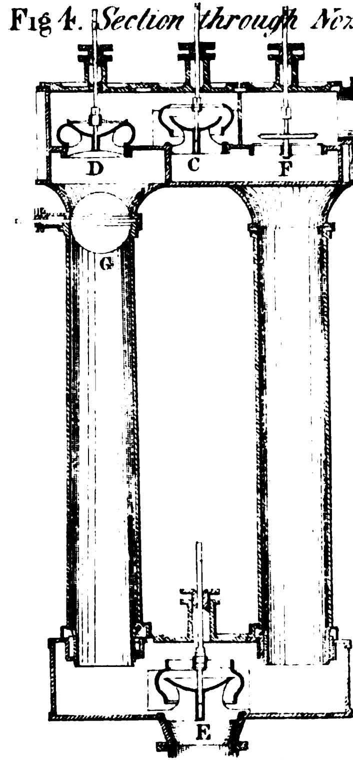
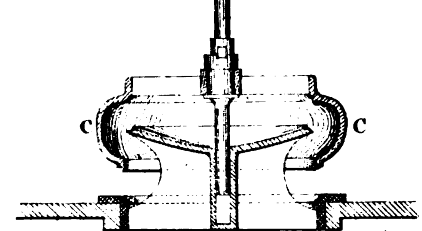
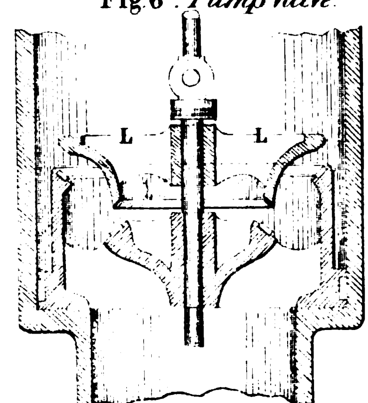


Fig 5. Steam Valve.



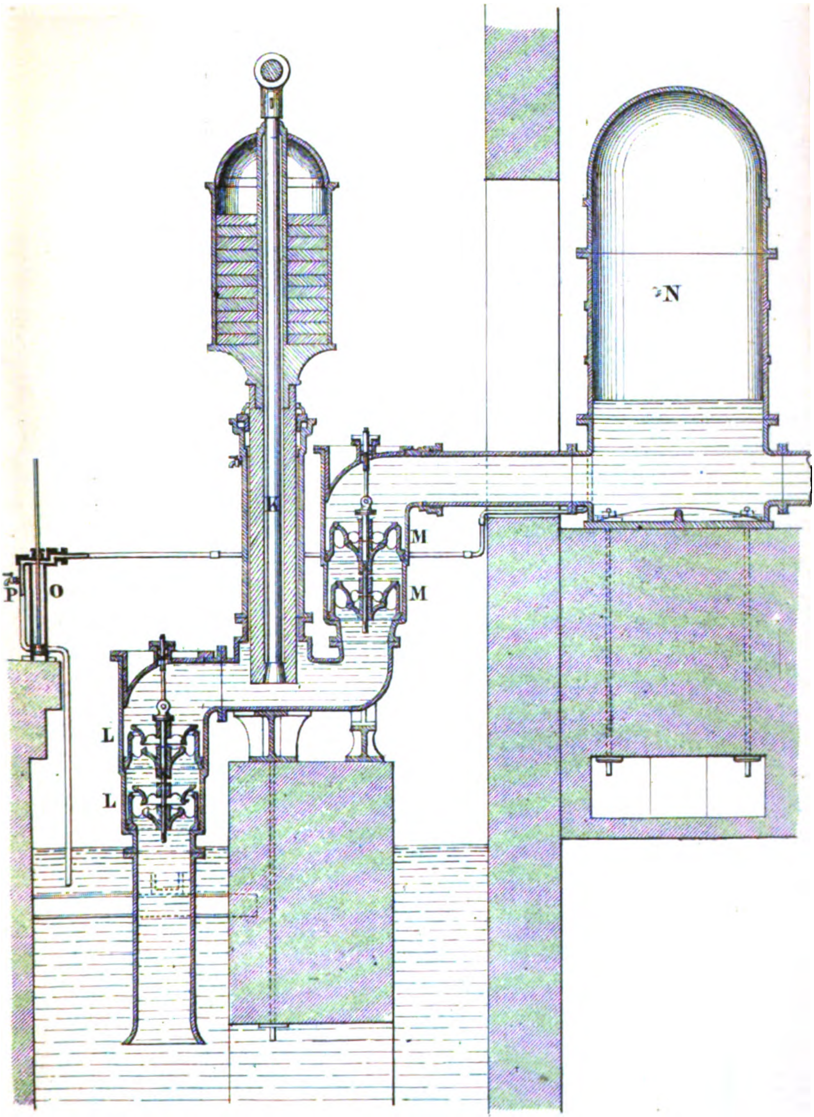
Scale 1/12th

Fig 6. Pump Valve.



Scale 1/12th

Fig. 7. *Longitudinal Section of Pump.*



Scale 1/96th 0 5 10 15 20 Feet

Fig 1. *Escape Water Valve applied to Horizontal Cylinder.*

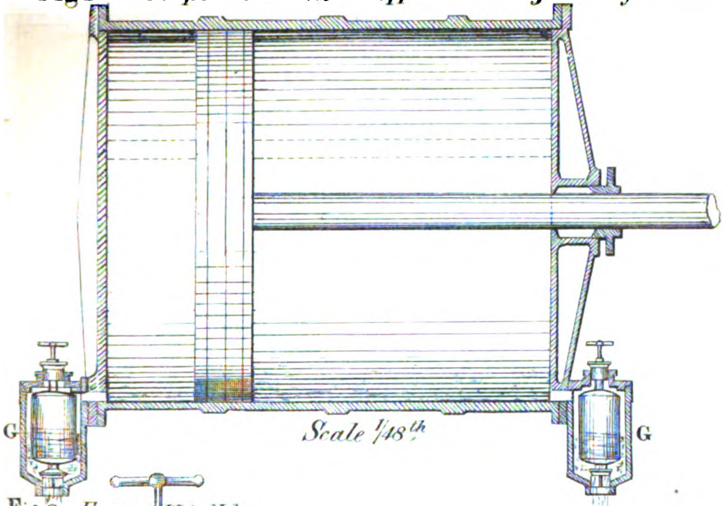


Fig 2. *Escape Water Valve.*

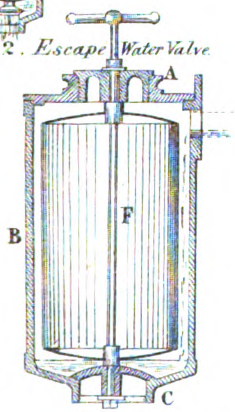


Fig 3. *Marine Engine Governor.*

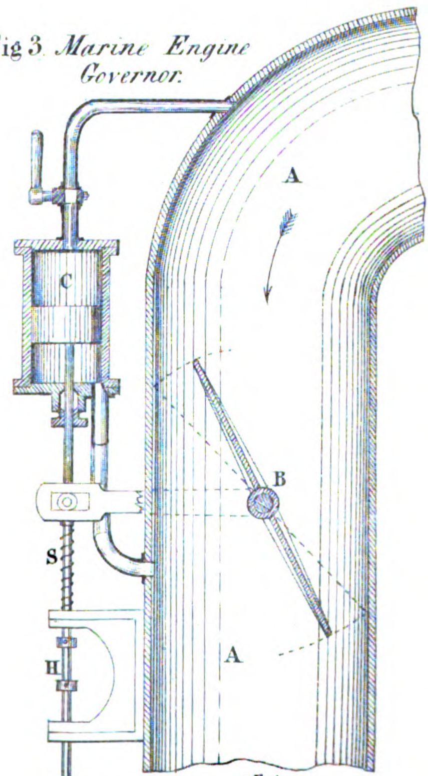
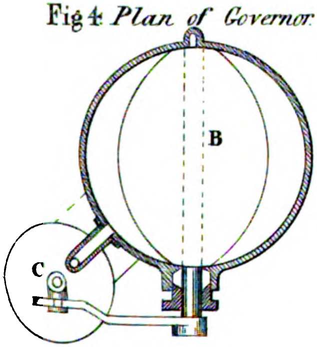


Fig 4. *Plan of Governor.*



Scale 1/16th 12 9 6 3 0 1 2 Feet.

COKING CRANE.

Fig. 1. *Elevation.*

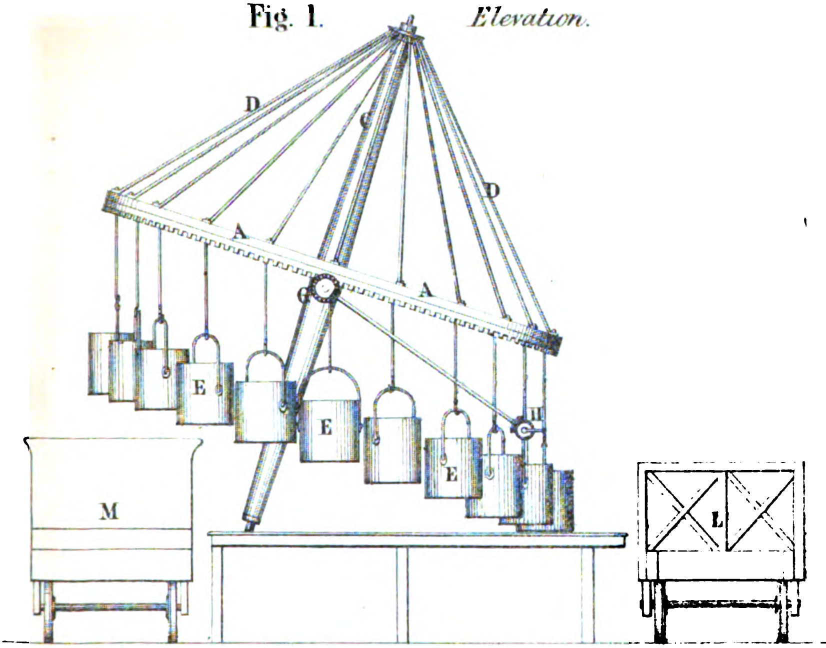
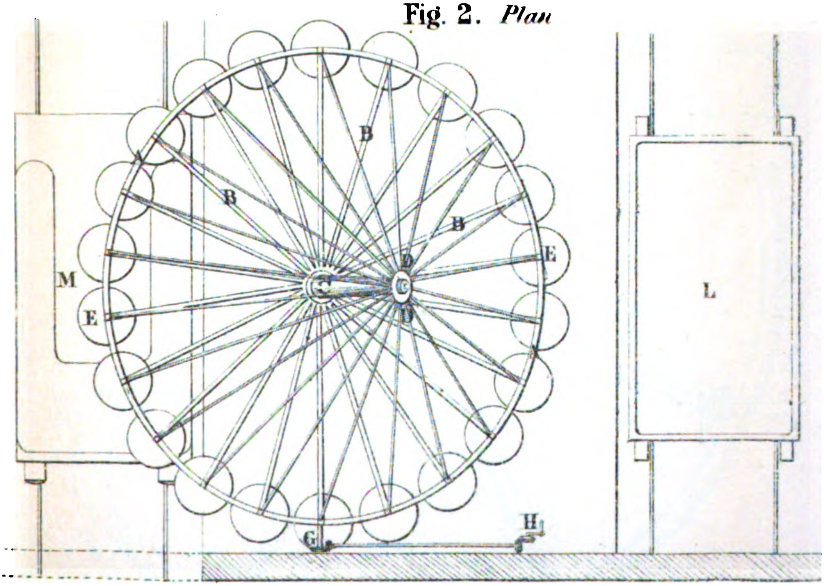


Fig. 2. *Plan*



Scale 1/96th 0 5 10 15 20 Feet

Sections of Roller Turntables.

Fig 1. Fig 3. Fig 4. Fig 5.

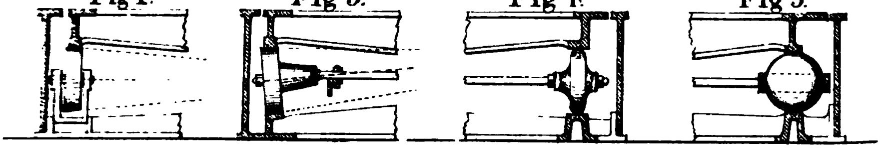
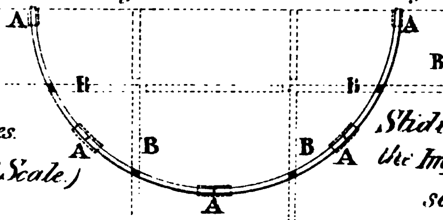


Fig 2. *Plan showing the extent of bearing Surface.*

A.A. *Bearing Surface in Roller Tables.* *(Half Scale.)*



B.B. *Bearing Surface on Sliding Blocks in the Improved Table* see Fig 10.

Fig 6. *Section of Centre Bearing Turntable.*

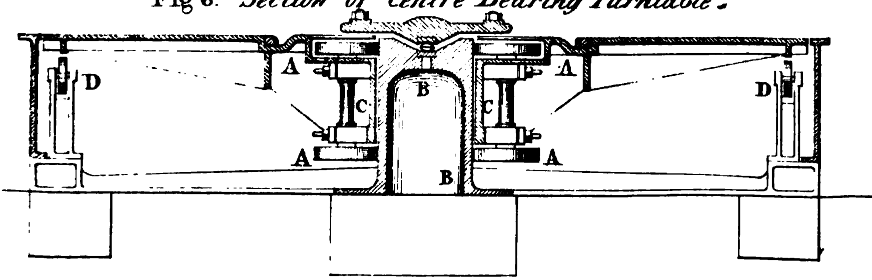
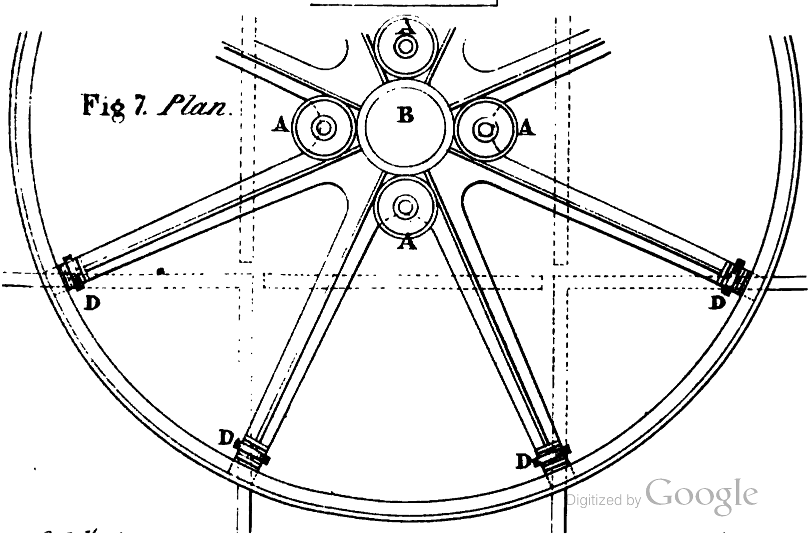


Fig 7. *Plan.*



IMPROVED TURNTABLE.

Fig 8. *Section of Improved Turntable*

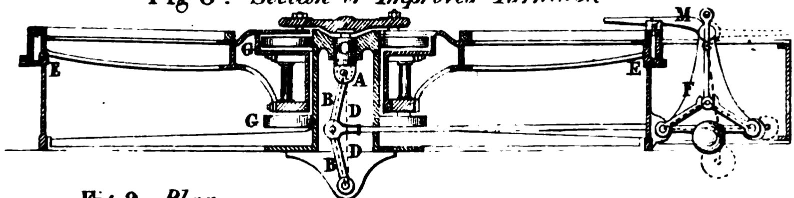


Fig 9. *Plan.*

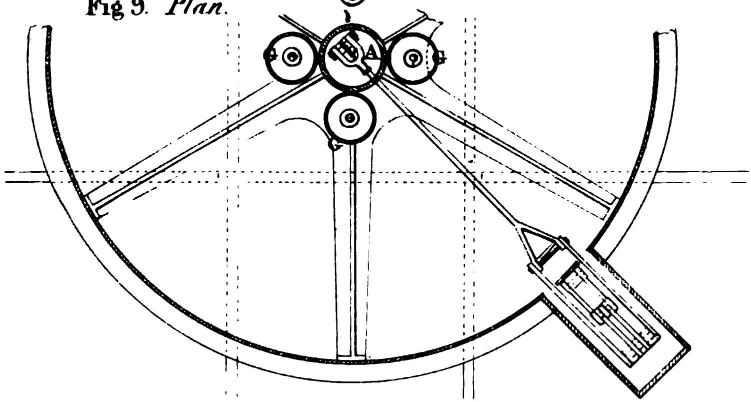


Fig 10. *Section of Turntable with Sliding Blocks.*

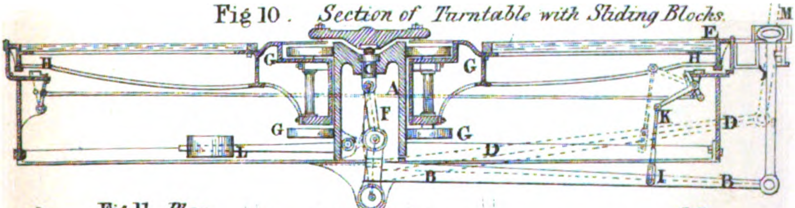
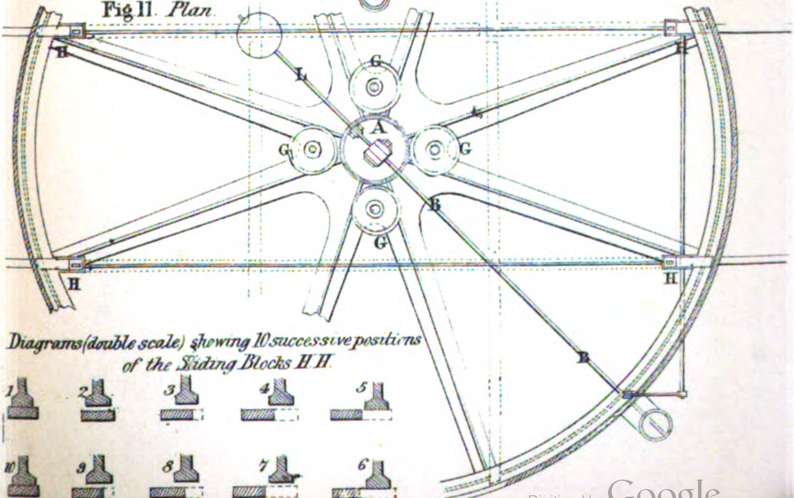


Fig 11. *Plan.*



Diagrams (double scale) showing 10 successive positions of the Sliding Blocks H H.

SAFETY BOILER APPARATUS.

Fig. 1.
Longitudinal Section

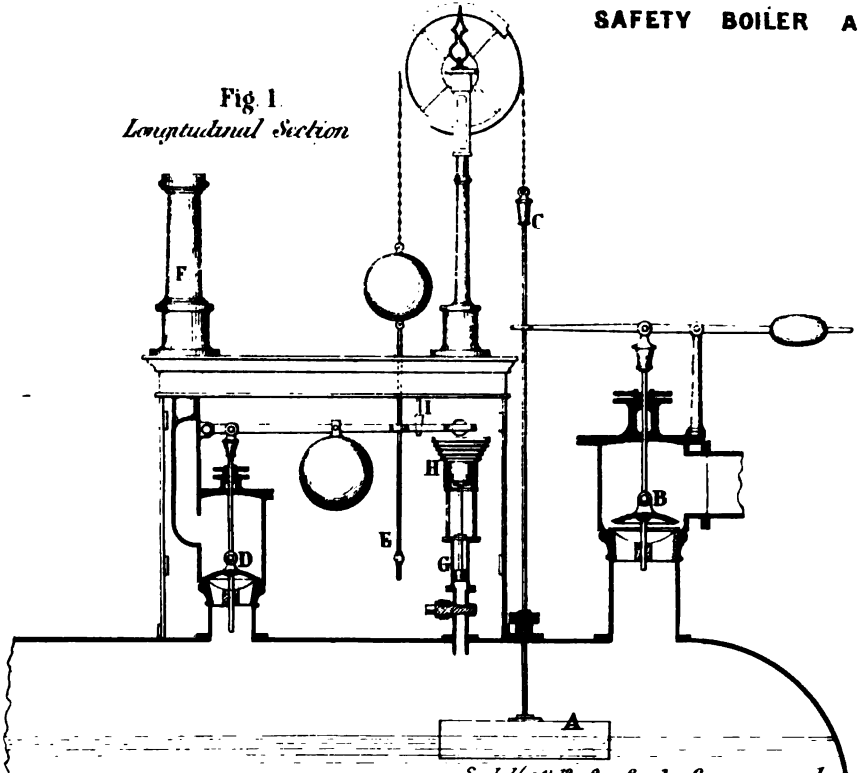
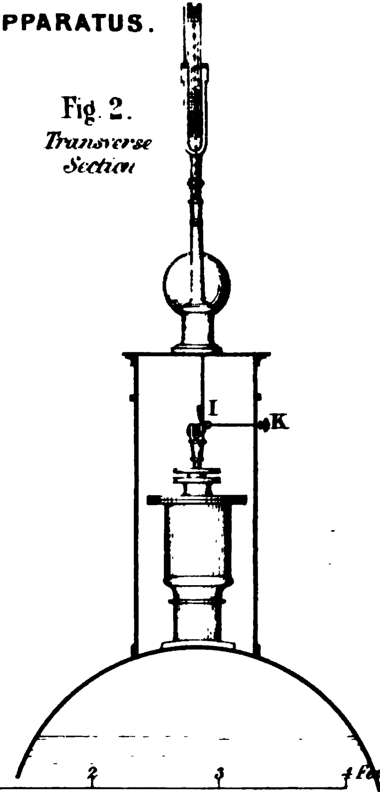


Fig. 2.
Transverse Section

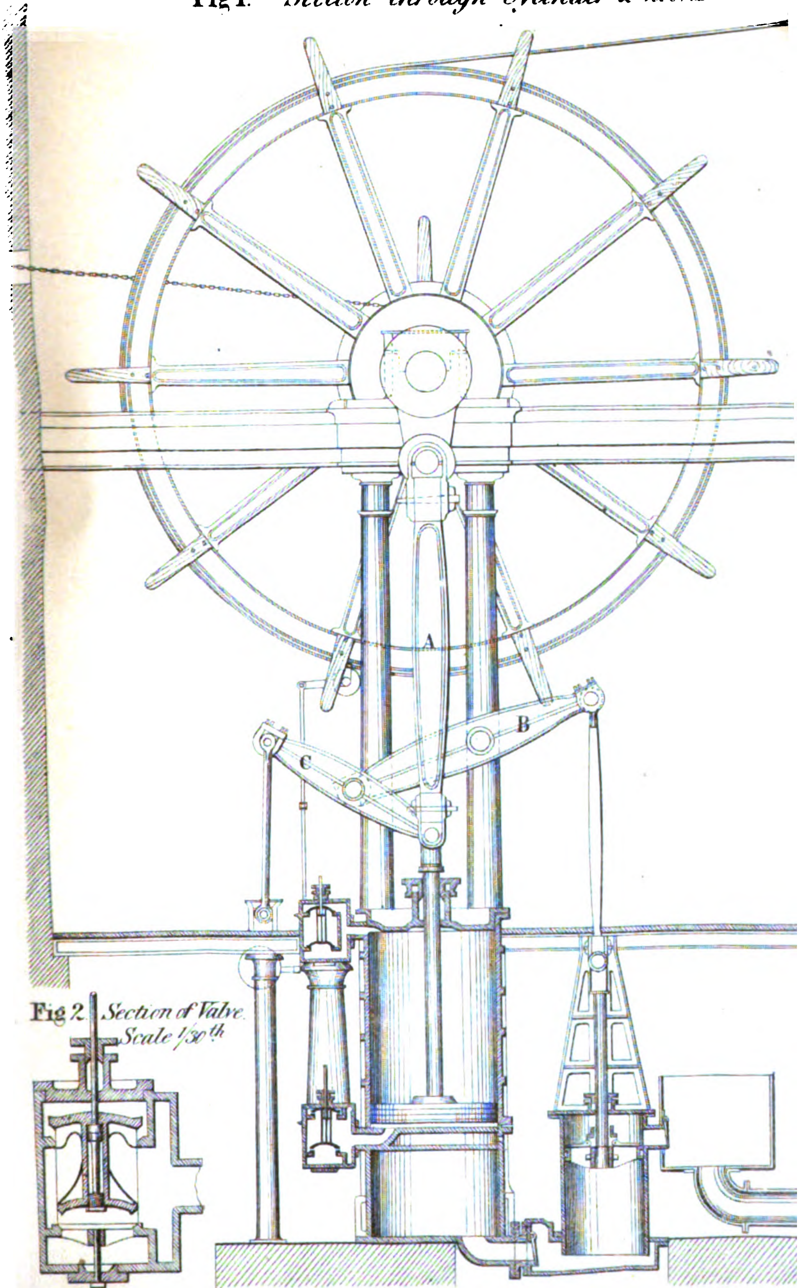


Scale 1/18th 12 9 6 3 0 1 2 3 4 Feet

Plat

WINDING ENGINE.

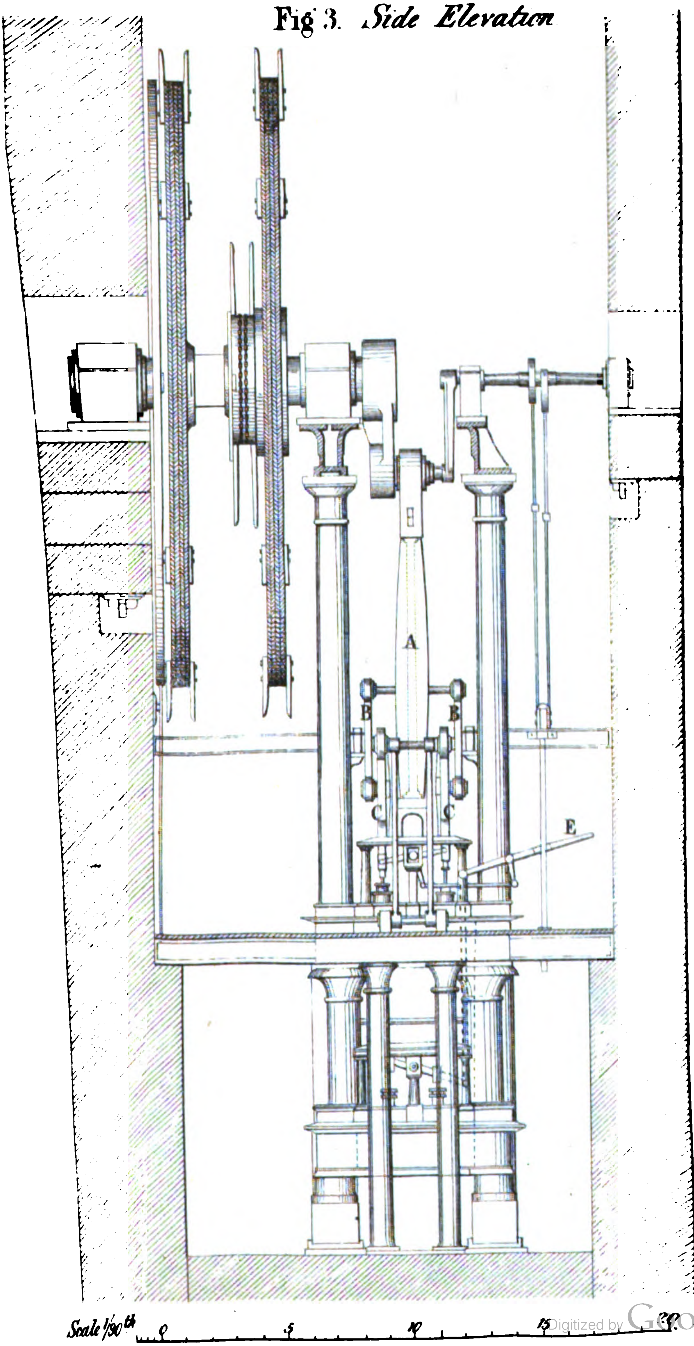
Fig 1. *Section through Cylinder & Valves*



Scale 1/30th 0 5 10 15 20 *Feet*

WINDING ENGINE.

Fig. 3. *Side Elevation*



CARTWRIGHT'S COMBING MACHINE.
1792.

Fig 1.

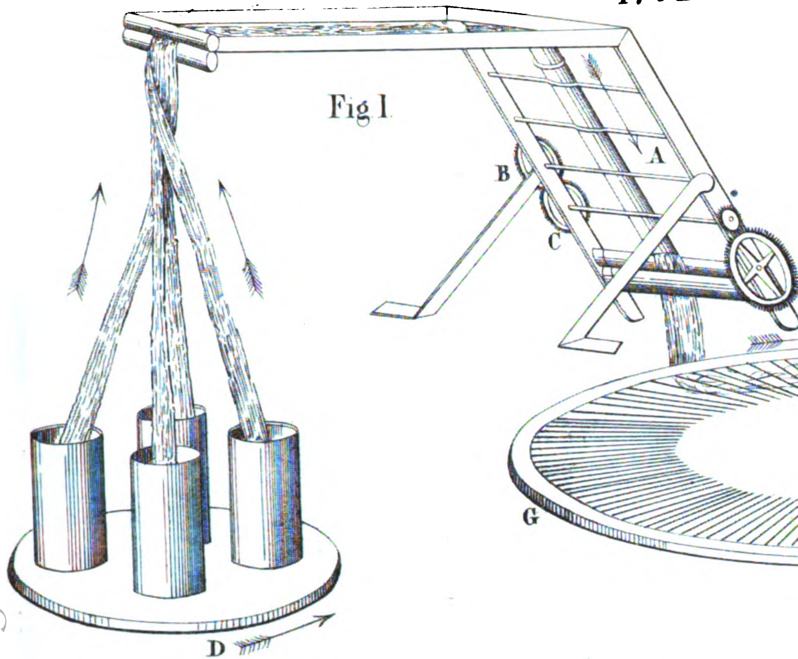
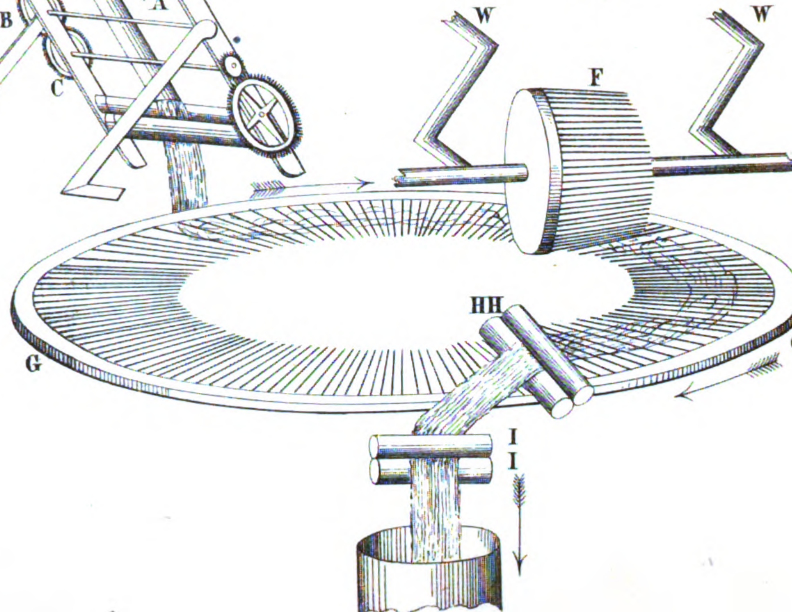
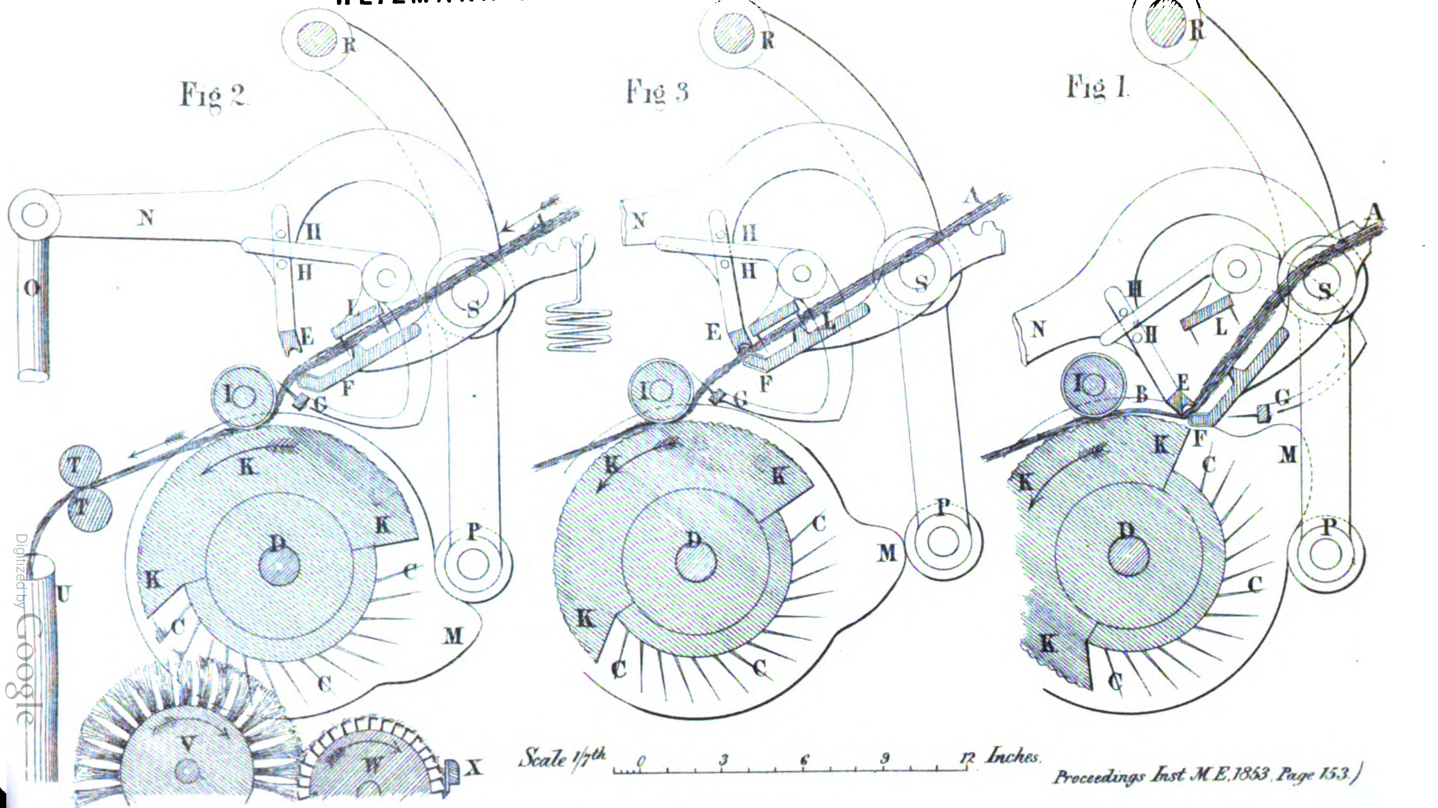


Fig 2.



(Proceedings Inst. M.E. 1853. Page 152.)

HEILMANN'S IMPROVED COMBING MACHINE.



Scale 1/7th 0 3 6 9 12 Inches.

Proceedings Inst M.E. 1853, Page 153.)

DRY-CLAY BRICK MAKING MACHINE.

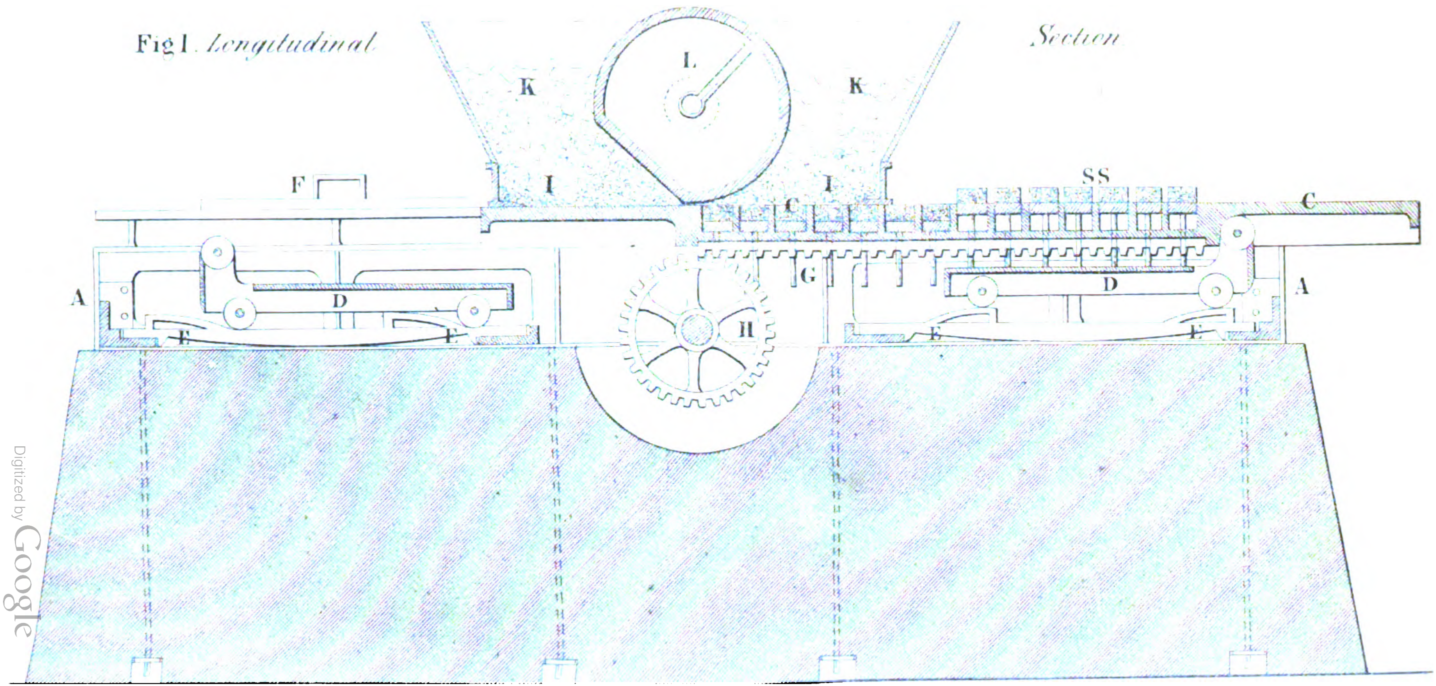
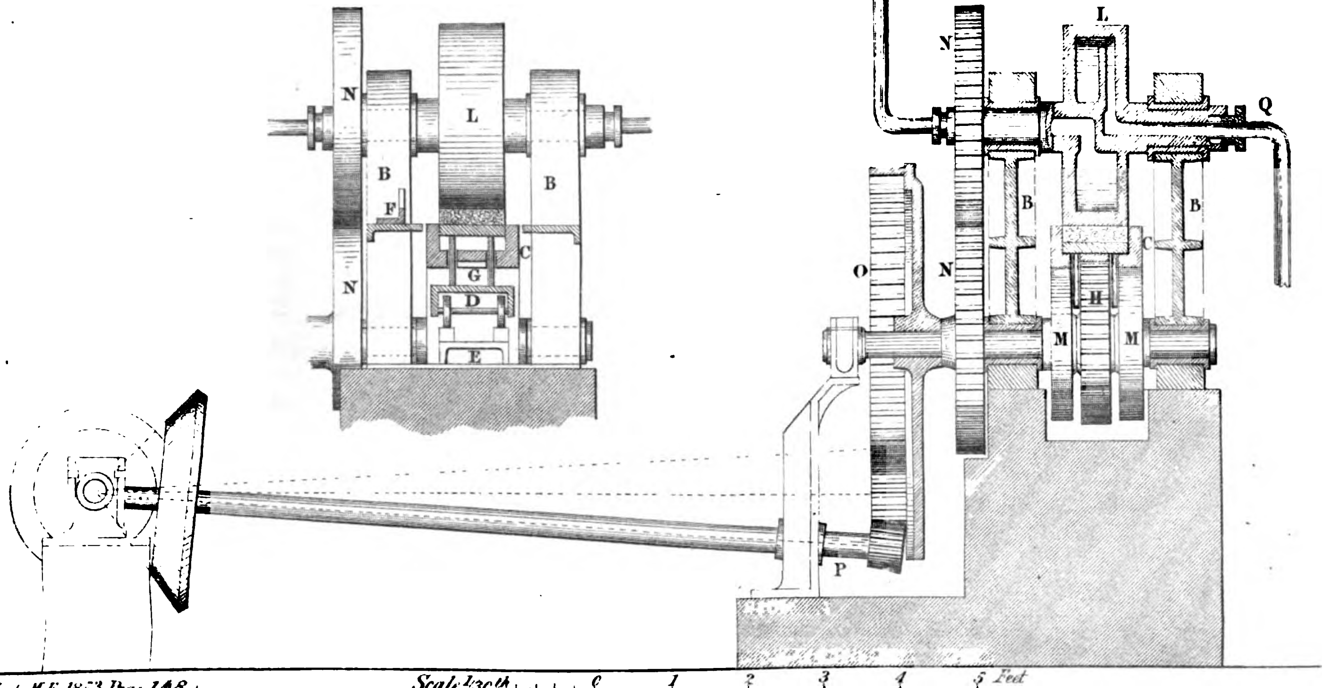


Fig 1. Longitudinal Section

DRY-CLAY BRICK MAKING MACHINE.

Fig. 3. *Transverse Section at S.S.*

Fig. 2. *Transverse Section at Centre.*

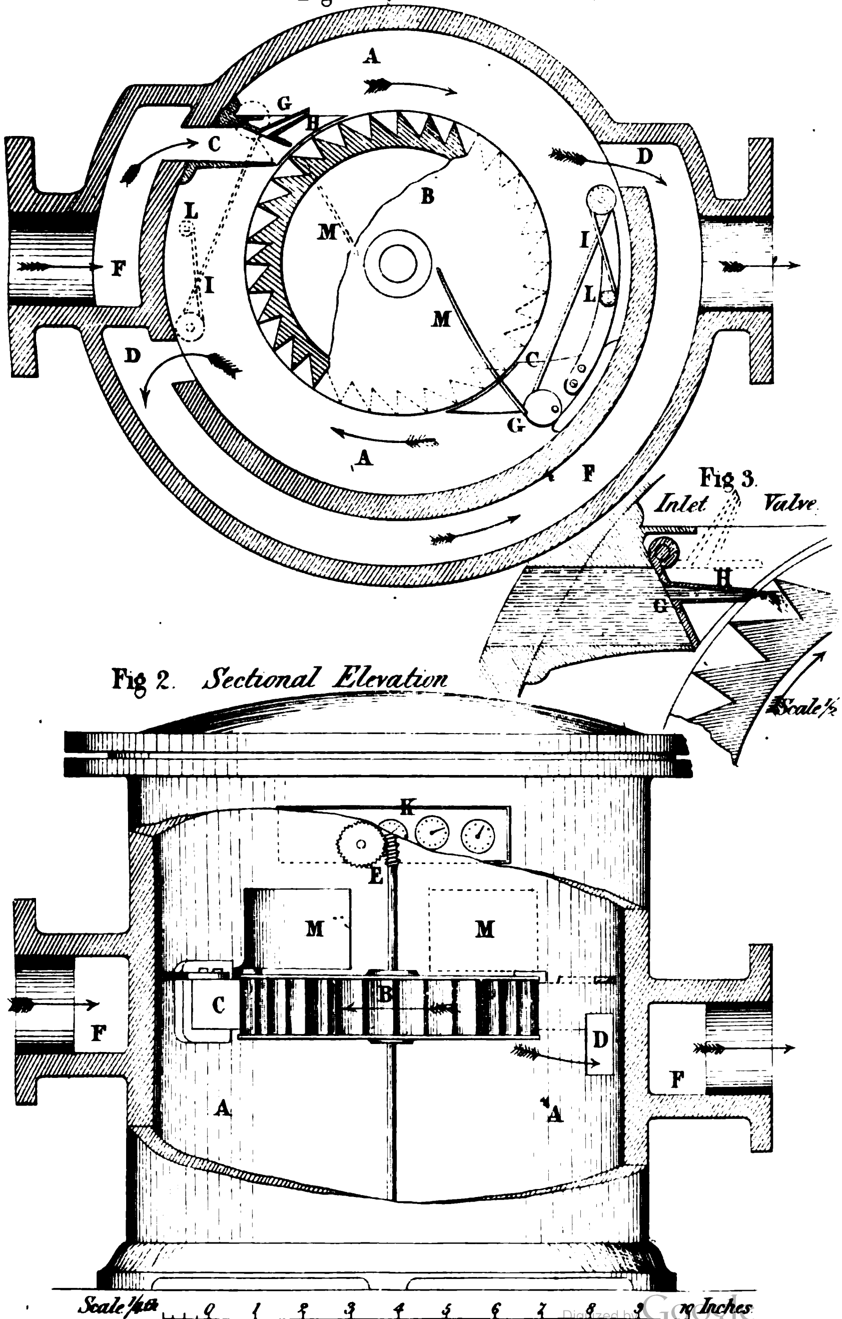


WATER METER.

Fig 1. *Sectional Plan*

Fig 2. *Sectional Elevation*

Fig 3. *Inlet Valve.*



NEWALL'S RAILWAY BREAK.

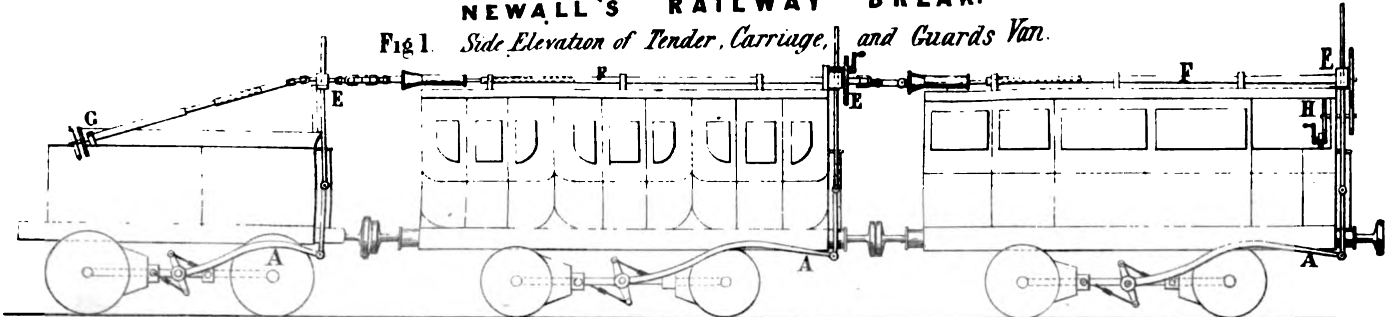


Fig 1. Side Elevation of Tender, Carriage, and Guards Van.

Scale 1/96th size.

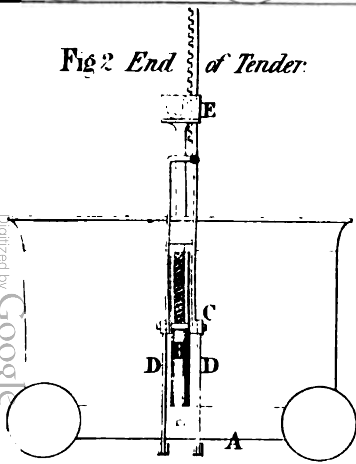
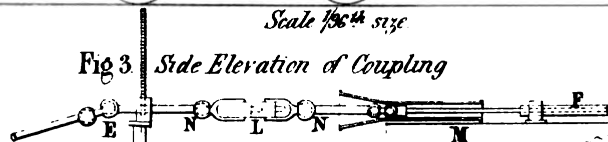


Fig 2. End of Tender.



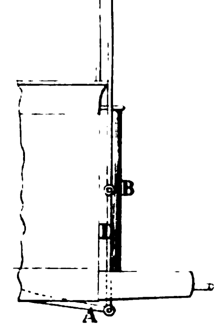


Fig 3. Side Elevation of Coupling

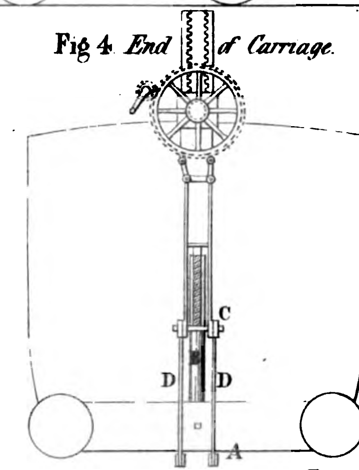


Fig 4. End of Carriage.

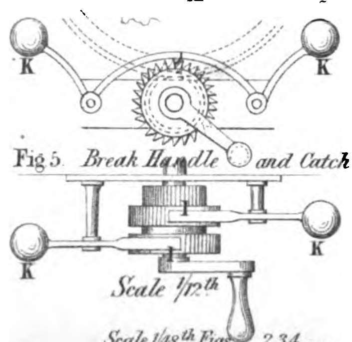


Fig 5. Break Handle and Catch.

Scale 1/12th

Scale 1/48th Figs. 2.3.4. 0 1 2 3 4 5 6 Feet

CENTRIFUGAL PUMP

Fig 1.

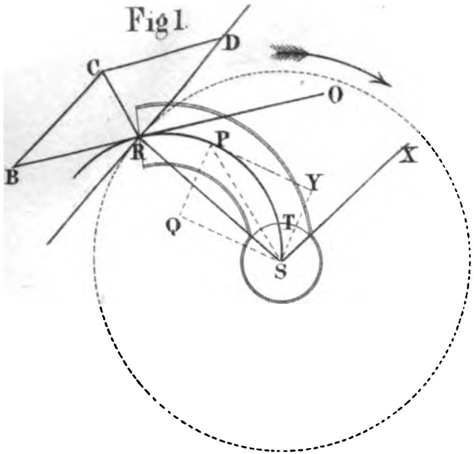


Fig 2.

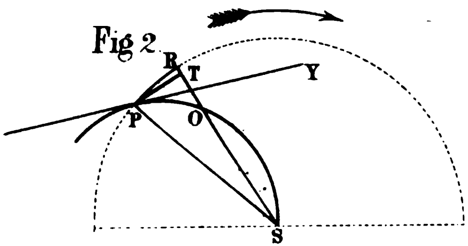


Fig 3.

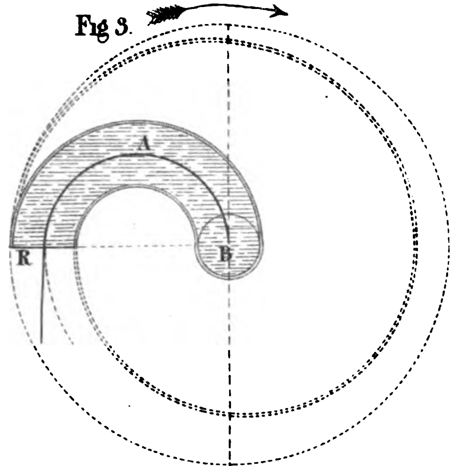


Fig 4.

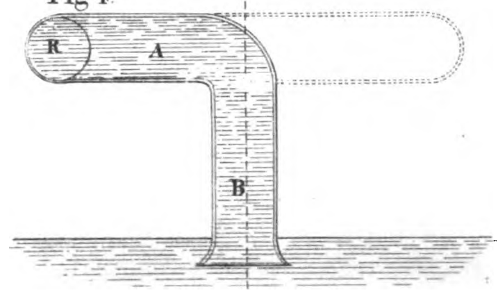


Fig 5.

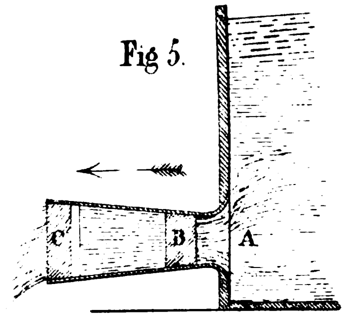
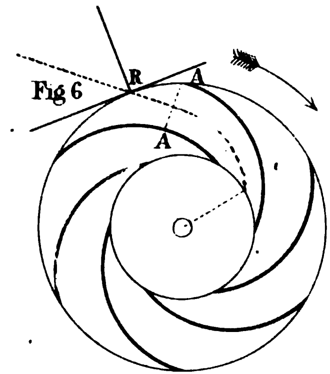


Fig 6.



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